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A REVISION OF THE INDO-MALAYAN SPECIES OF *VISCUM* LINN.*

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Introduction

During the study of the sheets of *Viscum* L. of the Calcutta Herbarium, the writer met with several species and varieties not recorded from various places of India and Burma by Danser in his revision of the British Indian species of *Viscum* in 1941 [*Blumea,* **4** (2)] as he could not consult the Calcutta Herbarium sheets for his revision. Further, the specific status of certain species is not fully justified. As such, the present revision as an extension of Danser's has become necessary.

This revision has considerably augmented the number of species and varieties known for India and Burma and further enlarged areas of distribution of many species. Danser in his paper (*loc. cit.*) mentions 17 species for the area. Of these, the writer has merged 2 species with the original species, giving a varietal status to one of them. This reduces the total number of species for the area under study to 15. A new variety has been described. A few species and varieties have also been newly recorded for the various regions in India and the neighbouring areas.

For the sake of brevity, the various synonyms given in different works pertaining to the floras of the Indo-Malayan region only, have been given. References to other works were given by Danser (*loc. cit.*). Descriptions based on the Calcutta Herbarium specimens and partly adopted from Danser (*loc. cit.*) have been included. Notes on distribution and various points of doubts regarding certain specimens raised by Danser (*loc. cit.*) have also been added, together with small distribution maps and illustrations of the 15 species.

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* The work was carried out at the Herbarium of the Indian Botanic Garden, Calcutta, and the paper was read at the Forty-second Session of the Indian Science Congress, Baroda, 1955.
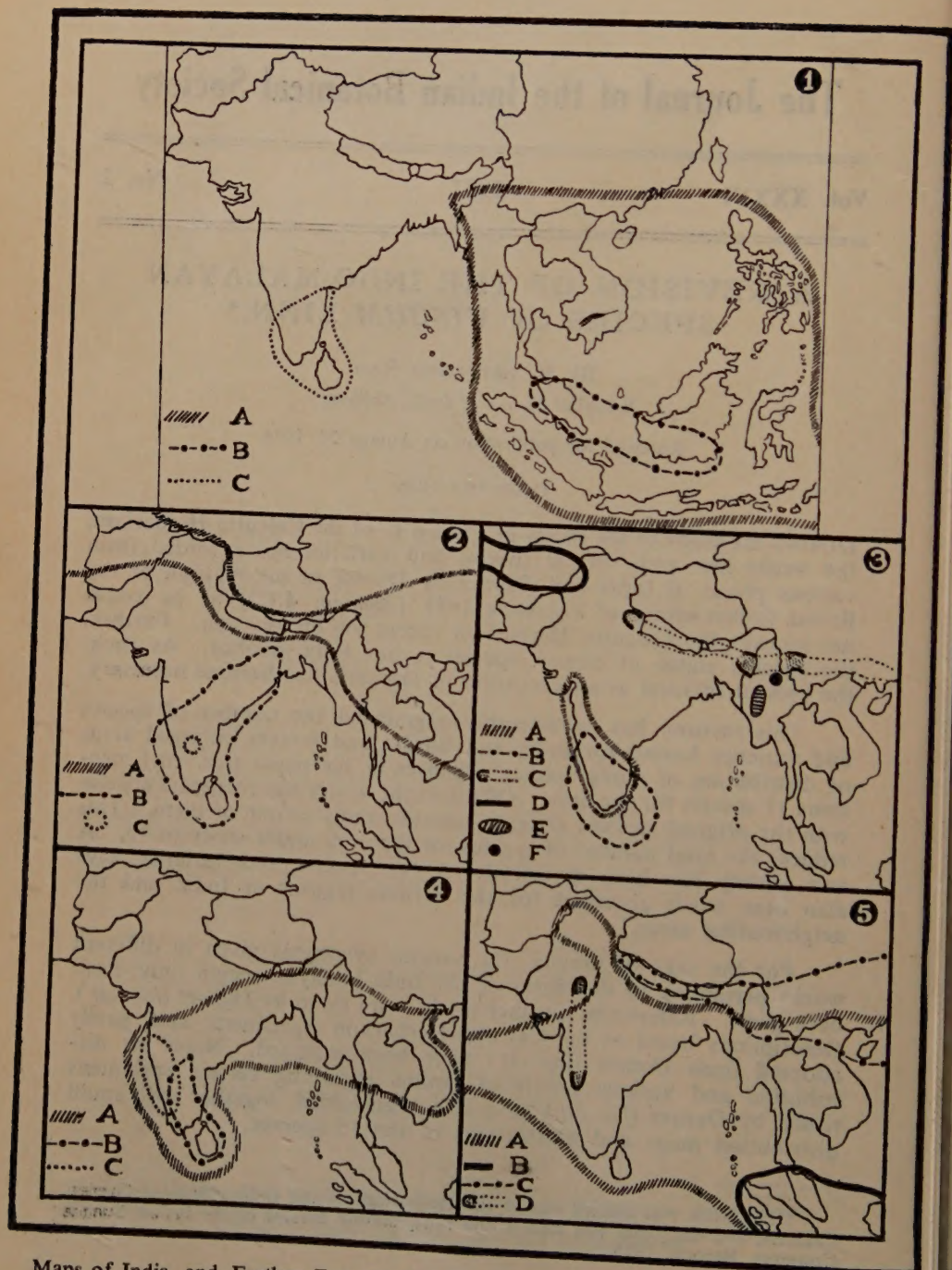
Maps of India and Farther East showing the distribution of the Indo-Malayan Species of *Viscum* Linn.

MAP 1. A—*Viscum ovalifolium* A.P. de Cand.
　　　　B—*Viscum wrayi* Gamble.
　　　　C—*Viscum heyneanum* A.P. de Cand.

MAP 2. A—*Viscum album* Linn.
　　　　B—*Viscum orientale* Willd.
　　　　C—*Viscum mysorense* Gamble.

MAP 3. A—*Viscum angulatum* Heyne ex de Cand.
　　　　B—*Viscum capitellatum* Smith.
　　　　C—*Viscum loranthi* Elmer (Discontinuous distribution).
　　　　D—*Viscum cruciatum* Boiss.
　　　　E—*Viscum acaciæ* Danser.
　　　　F—*Viscum acaciæ* var. *obovalifolium* Sesh.

MAP 4. A—*Viscum monoicum* Roxb. ex A.P. de Cand.
　　　　B—*Viscum ramosissimum* Wt. & Arn.
　　　　C—*Viscum trilobatum* Talbot.

MAP 5. A—*Viscum articulatum* Burm.
　　　　B—*Viscum articulatum* var. *flexuosum* (Gamb.) Danser.
　　　　C—*Viscum articulatum* var. *liquidambaricolum* (Hayata) Sesh.
　　　　D—*Viscum articulatum* var. *thelocarpum* (Danser) Sesh. (Discontinuous distribution).

HISTORY OF THE EARLY WORK ON THE GENUS

Linneaus in his first edition of "Species Plantarum" (1753) recognised the genera, *Scurrula, Loranthus* and *Viscum* which are now considered under Loranthceæ. In 1754 they were validly published in the 5th edition of *Genera Plantarum.* Since then, *Viscum* L. has always been used in the right sense.

Korthals[1] in 1839 made the first attempt to classify *Viscum*, dividing it into 4 sections—(1) *Viscum verum*, (2) *Ploionuxia*, (3) *Aspidixia*, (4) *Baratostachys*. The knowledge of Korthals at that time was limited to only European *Viscum album* and a few species of Asia and of America, the latter having now been removed to other genera. Later in 1896, Van Tieghem[2] followed another method subdividing *Viscum* into two genera, (1) *Viscum* and (2) *Aspidixia*, the latter being based on Korthals' section, *Aspidixia*. Though Van Tieghem rightly preferred to base his distinctions of genera and sections upon the structure of inflorescence rather than the development of leaves, he did this in a wrong way. Later in 1897, Engler[3] rightly uniting *Aspidixia* with *Viscum*, subdivided the genus on the basis of the structure of inflorescence but erroneously followed Van Tieghem in many details. In 1941, Danser (*loc. cit.*) proposed an arrangement distinguishing the genus into more natural groups on the basis of the structure of inflorescence. Discussing the merits and demerits of the early classifications in this paper may be superfluous as they had been well discussed by Danser (*loc. cit.*).

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[1] *Verhand. Batav Genootsch.*, **17**: 235–36, 1839.
[2] *Bull. Soc. Bot. France*, **43**: 187–93, 1896.
[3] Engl. and Pr., *Nat. Pfl. fam.*, **1**: 1897, 139.

DISTRIBUTION

The genus is mainly distributed in the tropical zones though very few species occur in the temperate regions. Africa claims the largest number of species, as many as 50, particularly in the Central and Southern zones which seem to be the centre of richest development, Madagaskar about 40 species, India 14 species, Burma 7, East Indies 6, Indo-China and Siam 8, Philippines 3, China and Formosa 9, Tropical Australia 3, New Zealand 1 and Japan 1 species. *Viscum album* Linn. and *V. cruciatum* Seib. et Boiss. appear to be the only two species occurring in temperate regions like Europe. On the basis of the available data, it appears that the line of distribution might have proceeded from Africa to India through Madagaskar and gradually extended further East as far as Japan on one side and tropical Australia on the other.

KEY TO THE SPECIES

The arrangement of the species given below is chiefly based upon Danser's with the necessary alterations to bring out a suitable key for the Indo-Malayan species of *Viscum*.

I.   No adventitious flowers in the cymes.

  A.   Flowers in usually 1–5 flowered spikes with terminal flower which, if female, usually with a bracteal cup of its own.

   1.   Flowering part of the plant with terminal inflorescences on the apex of all internodes. Lateral inflorescences present or absent. Diœcious species.
   (a) Leafy. (All species.)

     (i) Leaves very commonly large, female cymes 3–5 flowered, the lateral flowers in 1–2 decussate pairs; male flowers smaller, roundish in bud with tepals 2 mm. long; fruits sessile.............**V. ALBUM** 1

     (ii) Leaves very commonly smaller, female cymes with not more than 3 flowers; male flowers larger, oblong—ovate in bud with tepals 6–8 mm. long; fruits stalked...........**V. CRUCIATUM** 2

   2.   Flowering part of the plant usually with numerous lateral inflorescences only and exceptionally with terminal inflorescences at the tips of weak branches. Monœcious species.
   (a) Leafy.

     (i) Leaves partly normally developed and partly reduced to scales, yellow when dry; central flower of each cyme subtended by a bracteal cup of its own; fruits sessile............**V. MYSORENSE** 3

(b) Leafless or leaves scaly and very indistinct.

(i) Flowering stems with distinctly flattened internodes of varying breadth 2–10 mm., broadening gradually from base to top, decussate but twisted near the base to appear as in one plane, much longitudinally grooved; fruits globose or oblong, usually large..................
................**V. ARTICULATUM 4**

(ii) Flowering stems with distinctly 4-angular internodes; fruits globose or ovate, always smaller.......**V. ANGULATUM 5**

(iii) Flowering stems with distinctly round internodes often terete or grooved; (leaves invariably absent though recorded in rare cases); fruits sub-globose always very small ....**V. RAMOSISSIMUM 6**

(iv) Flowering stems stiff, divaricately branched, internodes round with a granular dull— shimmering surface, slightly wrinkled or grooved; inflorescences much crowded all round the nodes appearing as verticillaster; fruits smaller, oval with persistent tepals..........**V. LORANTHI 7**

B. Spikes reduced to triads with the middle flower female, the lateral flowers male.

(a) Leafy. (All species.)

(i) Flowering stems with internodes round and slightly grooved; leaves larger usually ovate rarely lanceolate and falcate, venation usually distinct; mature fruits distinctly warty, almost sessile.............**V. OVALIFOLIUM 8**

(ii) Flowering stems with internodes gradually flattened from base upwards; leaves distinctly obovate with broad rotund apex and smooth glossy surface, venation indistinct; mature fruits smooth, shortly stalked.................**V. WRAYI 9**

(iii) Flowering stems with internodes very slender, terete, not flattened at any region; leaves invariably lanceolate to spathulate with 3 nearly distinct longitudinal nerves; fruits smooth, prominently stalked.........**V. ACACIAE 10**

II. Inflorescence enlarged by the development of adventitious flowers.

 A. Middle flower of the cymes female.

  (*a*) Leafy. (All species.)

   (i) Leaves mostly ovate with obtuse or rounded apex; fruits mostly ovoid, contracted at the apex, dull by minute granular dots but never warty........ ....**V. ORIENTALE** 11

   (ii) Leaves mostly ovate with obtuse or acute apex; unripe fruits oblong, attenuate at both ends, warty, nearly smooth when ripened, tepals usually persistent.............**V. HEYNEANUM** 12

   (iii) Leaves mostly lanceolate, slightly falcate with acute or somewhat acuminate apex; fruits oblong, somewhat truncate but never attenuate nor contracted at the apex, smooth......**V. MONOICUM** 13

 B. Middle flower of the cymes male.

  (*a*) Leafy. (All species.)

   (i) Leaves larger, rotund to cuneate, broadly rounded to truncate, sometimes with two small depressions at the apex, 1·5–4·5 cm. long, 1–4 cm. broad; peduncles of cymes absent or usually not more than 2 mm. long............. ....**V. TRILOBATUM** 14

   (ii) Leaves much smaller, roundish—obovate with obtuse apex, always curled upwards, not more than 2 cm. long; peduncles of cymes prominent, 3–15 mm. long.........**V. CAPITELLATUM** 15

ENUMERATION OF SPECIES

 Besides the references to literature, synonymy and detailed descriptions of the species as given by Danser (*loc. cit.*), several points bearing on the collections of the Calcutta Herbarium and other Indian Herbaria which have not been properly discussed by Danser, are dealt with under each species.

  1. Viscum album Linn., *Sp. Pl.* (ed. 1), **2**: 1023, 1753; Brandis, *For. Fl. N.-W. & Centr. India*, 392, 1874; Kurz, *For. Fl. Burma*, **2**: 323, 1877; Boissier, *Fl. Orient.*, **4**: 1065, 1879; Aitchison in *Jour. Linn. Soc., Bot.*, **18**: 92, 1880 pro parte;

Bentham et Hooker, *Gen. Pl.*, **3**: 213, 1880; Hooker, f.,
Fl. Br. Ind. **5**: 223, 1886; Engler in *Nat. Pflanzenfam.*,
140, 1897; Gamble, *Ind. Timb.*, 583, 1902; Collet, *Fl.
Simlensis*, 440, 1902; Brandis, *Ind. Trees*, 552, 1906;
Parker, *Forest Fl. Punjab*, 441, 1924; Fischer in *Rec. Bot.
Surv. Ind.*, **11**: 160, 1926; Osmaston, *Forest Fl. Kumaon*,
465, 1927; Engler et Krause in *Nat. Pflanzenfam.* (ed. 2),
16 *b*: 199, 1935; Danser in *Blumea*, **2**: 55, 1936; Danser
in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **16**: 58, 1938; Danser
in *Blumea*, **4**: 268, 1941; *Viscum dichotomum* Giliberg,
Exercit., **2**: 394, 1792; *Viscum stellatum* D. Don., *Prodr.
Fl. Nepal*, 142, 1825; *Viscum album* var. *karensium* Kurz,
For. Fl. Burma, **2**: 323, 1877; *Viscum aitchisoni* Van Tieghem
in *Bull. Soc. Bot. Fr.*, **43**: 190, 1896 (nom. nud., pro parte);
Viscum costatum Gamble in *Kew Bull.*, **1913**: 46, 1913;
Viscum coloratum Nakai in *Mori Enum. Pl. Corean.*, 128,
1922. *Viscum album* var. *meridianum* Danser in *Blumea*, **4**:
274, 1941.

Plants dioecious. *Stems* dichotomously or umbellately branched
from the base, number of branches at each node usually 2–6, rarely
upto 13; internodes cylindrical, swollen at the nodes, green when fresh,
wrinkled when dried, each internode with two scaly leaves (prophylls)
on either side of its base and with two, vary rarely three normal leaves
at its apex. *Leaves* lanceolate or elliptic to obovate-lanceolate or obovate
or sometimes broadly obovate-cuneate, usually oblique with one side
straight and another with slight curvature, obtuse, or rounded, entire,
abruptly narrowed towards the base, sessile or subsessile, 2·5–10 cm.
long, 0·5–3·7 cm. broad, thin or coriaceous, curvinervous or flabel-
nervous with 3–9 indistinct or distinct longitudinal nerves connected
by indistinct reticulate veins. *Inflorescences* terminal on the top of
each internode between the two normal leaves and in the bifurcations of
the stems, sometimes on small internodes which in such cases are reduced
to pedunculate cymes. Male inflorescence nearly always 3-flowered,
the central subtended by a pair of small bracts decussate with the normal
leaves each of which bearing the lateral flower in its axils, peduncle
0–4 mm. long. Female inflorescence usually 3–5 flowered, the lateral
(lower) flowers produced in one or two decussate pairs of bracts one in
each of its axil, the central (terminal) flowers subtended (perhaps not
always) by a pair of bracts, peduncle 0–2 mm. long; bracts short and
round or longer and triangular. *Male flowers* nearly 2 mm. long with
4 valvate tepals and a very short tube. *Female flowers* considerably
smaller than the male ones with a short cylindrical ovary crowned by
4 thick triangular sepals and a short nipple-shaped style. *Fruits* sessile,
globose or roundish-elliptical, 4–8 mm. long, sometimes up to 13 mm.,
4–7 mm. in diameter, sometimes upto 9 mm. probably larger in fresh con-
dition. (Description from the Indian Plants of Calcutta and Shillong
Herbaria and partly adapted from Danser, *loc. cit.*). (Fig. 1.)

It is very interesting to note that the species exhibits extreme poly-
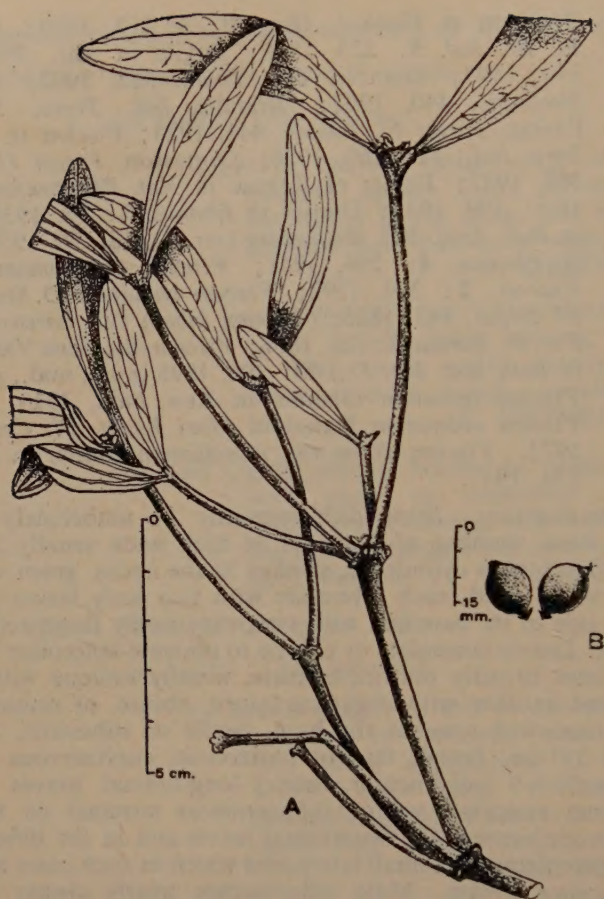morphy, showing variability in different parts of the plant, namely,

FIG. 1. *Viscum album* Linn. A. Shoot; B. Fruits.

the size of the plant itself, dimensions ($2 \cdot 5$–10 cm. in length and $0 \cdot 5$–$3 \cdot 7$ cm. in width), shape (from obovate-lanceolate to broadly obovate-cuneate with various intermediate shapes), texture and venation (3–9 longitudinal nerves) of the leaves and structure of inflorescence. In certain cases, the variability is so great that we may be tempted to form new species or varieties but the variation is not consistent and there are many intermediates connecting these variations. Danser also states " *V. album* is remarkably polymorphous. It seems, however, impossible to distinguish among the Himalayan forms any distinct varieties. Though we often meet with remarkable forms which are sufficiently different to be considered even as species, these forms are connected by so many intermediates, and their geographic distribution is so little characteristic, that even their distinction as varieties seems useless."

Specimens collected from Assam and Burma exhibit cuneate-obovate leaves with broadly rotund apex appearing much different from the rest, without, however, any difference in the structure of inflorescence. On the basis of this variation which is purely a geographic one, a new variety, *Viscum album* var. *meridianum* has been formed by Danser (Fig. 2). But close scrutiny of the various sheets indicates the

FIG. 2. *Viscum album* Linn. (*Type* of *V. album* var. *meridianum* Danser).

presence of both the normal and abnormal shapes of leaves on the same specimen and hence formation of a new variety on such an unstable character is not justified. Danser, while discussing about *V. album*

var. *karensium* Kurz, expresses his doubt whether it is a *Viscum* at all or may be his new variety *V. album* var. *meridianum* as he did not see Kurz's specimen. On examination of Kurz's sheet on which Kurz himself noted *V. album* var. *karensium* with a small diagram noting "invariably three tepals for all flowers," it is evident that it is quite similar to most of the specimens of *V. album* with much variation in the shape of the leaves. Further, the presence of three perianth lobes in *V. album* var. *karensium* as noted by Kurz could not be verified as there is no flower left with perianth on the sheet. However, it is evident on the basis of other characters that Kurz's variety is nothing but *V. album* proper.

The writer quite agrees with Danser as regards the structure and variation of inflorescence and the common occurrence of female plants among the Herbarium collections.

All the four sheets of *Viscum* of the Calcutta Herbarium collected by Aitchison from Kurram Valley in 1879 and received from the Kew Herbarium in 1881, bear two numbers 48 and 87. Of these only one contains 2 additional labels, one of which containing both the numbers 48 and 87 and the other which is the original label containing no. 87 only and also the notes "Loranthaceæ, mistletoe, from *Quercus ilex* grown near Turai village, profuse, 15–4–1879." This sheet contains 2 specimens, one *V. album* and the other *V. cruciatum*, the latter being attached to a small bit of host stem (probably Olive). The other 3 sheets having only one label, contain only one specimen on each which is distinctly *V. album*. These facts indicate that Aitchison's *V. album* is partly this species and partly *V. cruciatum* and the two numbers 48 and 87 together have been wrongly used for both the species *V. album* and *V. cruciatum*. Now, on the basis of the information given by Danser about Kew and Dehra Dun Herbarium sheets and that of the present sheet examined by the writer, it is clear that no. 48 indicated as a parasite on Olive on the Kew sheets, is *V. cruciatum* and that the no. 87 indicated as parasite on *Quercus* on the Calcutta sheet, is *V. album*.

Though the species has a very wide distribution in Europe and Western and Northern Asia, in India it is mostly confined to the Himalayan zone, that too, mostly in North-West Himalaya and quite rare in Nepal and Sikkim from where it might have spread to Assam and Burma, Yunnan (China), Tonkin (Indo-China) and Japan (Map. 2 A).

Specimens examined

> *Wall. Cat. no.* 490 (Nepal).

> INDIA : *E. Himalaya:* Sikkim, Rumul below Senchal, collected on 14–4–1857.

>> *C. Himalaya :* Nepal, *Maries.*

>> *W. Himalaya :* Dehra Dun, *Mackinon;* Chakrata, *Mackinon,* 25–1–1901; Tehri Gharwal, Lambataih 7,000 ft., *Gamble* 26736, 26737; Jaunsar Dn., Lambataih 8,000 ft., *Forster* 83; N.W. India, *Royle* s.n.; Pangee, *Dr. Stoliczt.;* 5–7,000 ft.

Thompson, s.n.; Hazara about 4,000 ft., *Stewart* 172, on peaches; Jaunsar Dt., Katuran 7,000 ft., *Gamble* 24174; Jaunsar Dt., Kathyar 7–8,000 ft., *Duthie* 13012, on apricot trees; Bashahr Serahu 7,000 ft., *Lace* 167; Nathia, *Deane* s.n.; Laram 7,000 ft., Chitral Expedition, *Gatacre* 17526; Pahalgam, Kashmir 8,000 ft., *Meebold* 4061; Kumaon, coll. *King*, Herb. King; Kurrum Valley, near Turai village, *Aitchison*, 15–4–1879, from *Quercus ilex*, profuse.

BURMA: Chin Hills, *Dun* 59; Burma, *Nobis* s.n., on *Thespesia*.

AFGANISTAN: Afganistan, *Griffith*, Kew distribution No. 2736; Bharovul, *Griffith*, Herb. Lemaon, 1852.

CHINA: China, *Faber*, 1887 to 1891; Central China, Hupeh Prov., *Henry* 7883.

JAPAN: Japan, *Maries*, 17–10–1884.

ASIA, WEST OF INDIA: Southern Syria, Mt. Hennon, *Lowne*.

ASIA, NORTH OF INDIA: Amur Medius, *Korshinsky*, 1891; Eastern Turkistan, Yarkand, *Henderson;* Caucasus, *Tepoah* s.n.

EUROPE AND ENGLAND: Ex Herbario Triburgensi, Romont 775 m., coll. ?; Flora exsiccata Austro-Hungarica, Borarlbergia, *Schonach* 2570; Bedfordshire, intelligible s.n.; Vantrilas, Hertfordshire, common on apple trees; Mont. Morency, *Stephan;* Broomfield, Essex, *Christy;* Windsor Park, Thirsk, Yorkshire, *Baker* 563.

The following specimens from India and Burma which were considered as *V. album* var. *meridianum* by Danser, are now treated as *V. album* proper:

INDIA: *E. Himalaya:* Sikkim, Darjeeling 7,000 ft., *Gamble* 371 C; *Assam*, Japu, Naga Hills, *Watt* 11477; * Naga Hills, Japu Forest, *De* 17461, "*Type* of *V. album* var. *meridianum* Danser" (Shillong Herb.* examined co-type also).

BURMA: Southern Shan States, Kalaw protected area, *Rogers* 694, coll. *Wright*, on *Salix tetrasperma;* Pegu, Nattoung, *Kurz* 372, "*V. album* var. *karensium* Kurz"; Martaban, *Kurz* 372, Forester's Herb. "*V. album* var. *karensium* Kurz".

2. **Viscum cruciatum** Boissier, *Vaj. Bot. Esp.*, **2**: 274, 1839–45; Van Tieghem in *Bull. Soc. Bot. Fr.*, **43**: 189, 243, 1896; Boissier, *Fl. Orient.*, **4**: 1068, 1897; Engler in *Nat. Pflanzenfam.*, 140, 1897; Hooker f. in *Bot. Mag. t.* 7828, 1902; *V. orientale* Sprengel, *Syst. Veg.*, **1**: 488, 1825 pro parte (non Willd.); A. P. de Candolle, *Prodr.*, **4**: 278, 1830, pro parte; *V. album* Webb., *It. hisp.*, 42, 1838 (non Linn.); Aitchison in *Jour. Linn. Soc. Bot.*, **18**: 92, 1800 pro parte; *V. aitchisoni* Van Tieghem in *Bull. Soc. Bot. Fr.*, **43**: 190, 1896 nomen, pro parte.

Plants diœcious. *Stems* once or twice branched in the basal region with decussate branches which are further branched dichotomously; internodes cylindrical, slightly swollen at the nodes, somewhat wrinkled in dried state, lower internodes usually 2·5–3·5 cm. long, 4–5 mm. in diameter, sometimes up to 5 cm. long, the upper ones gradually less thick with the topmost ones nearly flattened and reduced to 1 mm. in breadth; each branch subtended by 2 scaly leaves (prophylls) at its base. *Leaves* opposite, elliptic-lanceolate or somewhat obovate, rounded, entire, contracted at the base, almost sessile, usually 2–4 cm. long and 0·5–1·5 cm. broad, somewhat coriaceous, without visible nerves or with 3 longitudinal nerves visible on both sides. *Inflorescences* terminal in the bifurcations of stems and lateral on all the nodes, 2–4 together, shortly peduncled. Male inflorescences usually 3 flowered, flowers sessile, often reduced to the middle flower. Female inflorescences always 3 flowered with the middle flower rarely sessile with no bracts at its base but usually pedicelled and subtended by 2 small bracts, with the lateral sessile flowers placed in a naviculate cup formed of two opposite acute bracts. *Male flowers* oblong-ovate in bud, 6–8 mm. long, 4-angular towards the tip, later dividing into 4 lobes, anthers adnate on the innerside of tepals, dehiscence by many pores. *Female flowers* obovate, 1–2 mm. long, composed of a large inferior ovary and 4 triangular, minute, deciduous tepals and a small nipple-shaped persistent style. *Fruit* stalked, globose, up to 5 mm. in diameter. (Description from the specimens of N.-W. Frontier and Asia Minor in the Calcutta Herbarium and partly adapted from Danser *loc. cit.*) (Fig. 3).

Sieber first collected the species in Palestine and distributed it under the name of *Viscum cruciatum*. This was later erroneously identified and published by Sprengel and deCandolle as *Viscum orientale*. In 1839, Boissier rightly separated *Viscum cruciatum* from *V. orientale* validly published.

Though *V. cruciatum* appears to be quite distinct from *V. album*, it is sometimes difficult to distinguish both in all stages of development. The vegetative parts of young specimens of this species are comparatively smaller and particularly their twig generations are composed of more than one internode. The male plant is characterised by large 3-flowered inflorescence with the lateral flowers often reduced and the middle one much enlarged. In bud condition, the flowers are oblong-ovate. The female plant is clearly distinguished by the presence of a definite 3-sessile-flowered cyme with no separate bracts for the middle one but very often with the pedicellate middle flower with two small bracts. Danser remarks that the pedicellate character of the middle flower is rather rare. The fruits are definitely smaller and are never grouped more than three in one boat-shaped bracteal cup.

As regards Aitchison's collection of *V. cruciatum* from Kurram Valley, see the discussion under *V. album*.

This species is mostly confined to North-West Frontier, Afganisthan, Kurram Valley and different regions of Asia Minor like Palestine

FIG. 3. *Viscum cruciatum* Boiss. A. Shoot of female plant (*Lowne*); B & C. Female flowers; D. Male flowers from another twig (*Lowne*).

and Syria. A specimen collected from Spain appears to be the same species (Map 3 D).

Specimens examined

INDIA: North-West Frontier, Tarah expedition, Masture, 4,500 ft. *Inayat* 20934, female plant; Samana Range, *Hare* s.n., female plant; Kurram Valley, *Aitchison* 48 (mixed with *V. album*, *Aitchison* 87).

ASIA MINOR: Southern Syria, Nablous, *Lowne* s.n., male and female plants; Palestine, *Pinard* s.n., female plant; Palestine, *Boissier*, female plant;

EUROPE: Spain, Jaew Blanco, on *Pinus pinaster*.

3. **Viscum mysorense** Gamble in *Kew Bull.*, **1925**: 329, 1925; Gamble in *Fl. Madras*, **7**: 1257, 1259, 1925; Danser in *Blumea*, **4**: 279, 1941.

The following is the detailed description of species as given by Danser (*loc. cit.*).

All parts with a golden yellow colour. Only *stem* available. slender, over 50 cm. long, at nearly all the nodes di- or trichotomous, its basal portion terete, 5–6 cm. long, up to 3 mm. in diameter, longitudinally wrinkled, hardly striped, slightly thickened at the nodes, young internodes usually 2·5–4 cm. long, distinctly longitudinally striped with shallow grooves, nearly terete or slightly flattened near the base, 1–1·5 mm. broad, strongly alternately flattened and double-edged towards the apex, 2–3 mm. broad. *Leaves* normally developed only on a part of the nodes, the largest obtusely lanceolate to spathulate, up to 4 cm. long by 10 mm. broad, often smaller, rounded at the apex, tapering into a short petiole that is rounded beneath, flat or slightly canaliculate above, the lamina rather thick-coriaceous, with 3 longitudinal nerves, somewhat distinct above than beneath, connected by indistinct veins. Leaves scale-like on most of the nodes, nearly 0·5 mm. long, acute; also 2 scales (prophylls) at the base of all ramifications. *Inflorescences* rarely terminal, usually axillary or at both sides of the axillary ones, sessile or shortly pedunculate 1–3 flowered cymes; peduncle flattened, up to 1 mm. long and broad, bearing at its apex 2 opposite acute bracts forming together a naviculate cup up to 2 mm. long, each bearing one sessile flower in their axil devoid of a bracteal cup and usually male, rarely female, nearly 1 mm. long and compressed between the bract and the middle flower; a middle flower, female, rarely sessile and without bracteal cup, usually very shortly pedicellate and surrounded by a cup of two small bracts alternating with those of the lower pair. *Fruit* unknown. (Description from the type specimen in the Kew Herbarium.) (Fig. 4.)

The writer could not see the specimen as, it appears, there are only two specimens, one at Kew and another at Berlin-Dahlem, the former being the type of the species. On the basis of the description, it appears that the structure of the inflorescence is very characteristic of this species. It would be quite interesting if this species is again collected from Mysore region.

The species has so far been collected only from Arsikere, 2000 ft., Mysore by Meebold (*Meebold* 8207). It may be too premature to discuss about the distribution of this species at this stage (Map 2 C).

4. **Viscum articulatum** Burmannus, *Fl. Ind.*, 211, 1768; Kurz in *Jour. As. Soc. Beng.*, **40** (Pt. 2): 64, 1871; Kurz, *For. Fl. Burma*, **2**: 325, 1877 (incl. var. *dichotoma*); Hook. f. in *Fl. Br. Ind.*, **5**: 226, 1886 (incl. var. *dichotoma*); Brandis, *Ind. Trees*, 552 and 716, 1906; Gamble in *Jour. As. Soc. Beng.*, **75** (Pt. 2): 389, 1914; Gamble, *Manual Ind. Timbers*, 584, 1902; Cooke, *Fl. Bombay*, **2**: 553, 1906 (incl. var. *dichotoma*); Talbot, *For. Fl. Bomb.*, **2**: 423, 1906, t. 482; Duthie, *Fl. Upp. Gang. Pl.*, **3**: 65, 1915; Haines, *Bot. Bihar and Orissa*, **5**: 804, 1924; Parker, *For. Fl. Punjab*, 441,

Fɪɢ. 4. *Viscum mysorense* Gamble (drawn from the photo of *Type* specimen).

1924; Gamble, *Fl. Madras*, **7**: 1258, 1259, 1925 (incl. var. *dichotoma*); Fischer, in *Rec. Bot. Surv. Ind.*, **11**: 161, 181, 1926 (incl. var. *dichotoma*); Osmaston, *For. Fl. Kumaon*, 465, 1927; Kanjilal, *For. Fl. Philibit* etc., 319, 1933; Kanjilal, De and Das, *Fl. Assam*, **4**: 119, 1940; Danser in *Blumea*, **4**: 280, 1941; *Viscum flexuosum* Gamble in *Kew Bull.*, **1913**: 47, 1913; Gamble in *Jour. As. Soc. Beng.*, **75** (Pt. 2): 389, 1914; Ridley, *Fl. Mal. Pen.*, **3**: 165, 1924; *Viscum nepalense* Sprengel, *Syst. Veg.*, 47, 1827; Danser in *Blumea*, **4**: 283, 1941; Santapau in *Rec. Bot. Sur. Ind.*, **16**: 268, 1953 (excl. var. *thelocarpum*); *Viscum dichotomum* D. Don, *Prodr. Fl. Nepal*, 142, 1825 (non Gilibert 1792 and non Sprengel 1825); Gamble in *Jour. As. Soc. Beng.*, **75** (Pt. 2): 389, 1914; Ridley, *Fl. Mal. Pen.*, **3**: 165, 1924; *Viscum attenuatum* A.P. de Candolle, *Prodr.*, **4**: 284, 1830; Wight and Arnott, *Prodr. Pen. Ind. Or.*, 380, 1834; Thwaites,

Erum. Pl. Zeylan., 136, 1859; Brandis, *For. Fl. N.-W. &*
Centr. India, 394, 1874 pro parte;   Trimen, *Syst. Catal.*
Ceyl. Pl., 77, 1885; Engler in *Nat. Pflanzenfam.*, 140, 1897;
Viscum opuntioides Roxb. *Fl. Ind.* (ed. 2), 764, 1832 and
(ed. 3), 715, 1874;   *Viscum liquidambaricolum* Hayata,
Ic. Pl. Formos., **5**: 194, t. 71, 72, 1915; Danser in *Blumea*,
4: 289, 1941.

Plants monœcious. *Stems* dull green, slender, much branched,
hanging to 100 cm. or even more, branches generally decussate but
often more or less than two at each node; lower internodes of older
plants terete, of younger plants slightly flattened, 2–5 cm. long, inter-
nodes broadening gradually from base to top, twisted near the base,
longitudinally grooved, slightly thickened at nodes, internodes towards
the apex more flattened, 1–6 cm. long, 2–10 mm. broad with truncate
or rounded apex. *Leaves* scaly, hardly 1 mm. long, usually indistinct.
Inflorescences lateral at the nodes in small, sessile, cymose clusters,
2 mm. long and 2 mm. broad at maturity, usually 1–3, rarely 5-flowered,
first developing one terminal female flower subtended by two small
scaly bracts united into a cup, then a pair of lateral usually male flowers,
one on either side below the upper bracteal cup and partly in the axils
of another pair of lower, decussately developed bracts, without being
subtended by this lower pair; rarely another pair of male flowers and
a pair of bracts decussate to the second pair in similar arrangement
may be developed; often later (usually after falling off of male flowers)
two new flowers normally reduced to one female flower may develop
at the base of inflorescence; bracts of flowers about ·75 mm. long.
Fruits somewhat globose, and green when young and during maturity
shape varying from globose to slightly oval or even oblong and colour
changing to light yellow, usually 3–4 mm. in diameter, fruit-wall nearly
smooth when fresh and much wrinkled after drying, rarely warty when
young, pulp highly viscous, whitish. (Description from specimens in
Calcutta and Shillong Herbaria and fresh specimens with fruits from
Khasia hills and partly adapted from Danser (*loc. cit.*) (Fig. 5).

Danser (1941) distinguished *V. nepalense* and *V. liquidambaricolum*
from *V. articulatum* on the basis of the breadth of the internodes and
the size and shape of the fruit and thus treated them as distinct species.
Yet, he remarks that the size of the internode is not a dependable
character and there is some variation in the size and shape of the fruit.
On critical examination of the various sheets of this species available
at the Calcutta Herbarium which were not examined by Danser (prob-
ably not available at Kew), it appears there is much variability in the
size of internode and in the shape and size of fruit as it matures. Fur-
ther, there are quite a good number of specimens not examined by
Danser even from other Herbaria, which show intermediate characters
between   *V. articulatum*   and   *V. nepalense*,   and   *V. nepalense*   and
V. liquidambaricolum.

Danser (*loc. cit.*, p. 281) points out that "the real *V. articulatum*
has rather narrow or very narrow or more rarely rather broad, usually

FIG. 5. *Viscum articulatum* Burm. (Kew distr. No. 1248, *Herb. Wight*).

strongly flattened, internodes and small, globose, usually white or light yellowish fruits; it is usually parasitic on Loranthaceæ. The other leafless British Indian Visca are sometimes as narrow as *V. articulatum*, sometimes distinctly broader and have larger and darker coloured fruits; those fruits are either globose or more oblong and their exact colour, rarely indicated on the herbarium labels, seems to be yellow or brownish. They rarely seem to grow on Loranthaceæ."

In contrast to this, Danser admits that the width of internodes to distinguish the three species, is not at all dependable and the distinction among the three species is very difficult due to inadequate state of the herbarium materials with no notes and no flowers and fruits or sometimes with only shrivelled fruits which do not show real size

2

and colour. Still, on the basis of such material which exhibits such a variability, Danser, expressing some doubts about the specific rank of *V. nepalense* and *V. liquidambaricolum*, keeps them as two separate species to draw more attention to this question, suggesting more thorough study of the living plants of all these species from Assam to Perak where they occur together. Gamble in his earlier work distinguished *V. nepalense* Sprengel as *V. articulatum* var. *dichotomum* and later raised this variety to a specific rank as *V. dichotomum* on the basis of the breadth of internodes and diameter of fruit. But as this name is a later homonym and hence invalid, *V. nepalense* Spreng. was considered by Danser to be valid for this species.

From the close examination of the specimens collected from Peninsular India, Ceylon, Chota Nagpur and Central India, it appears that the distinction brought out by Gamble and Danser between *V. articulatum* and *V. nepalense* is not of stable nature and there is quite a good variation. Further, some specimens like *Gamble* 9210, *Hooper and Ramaswami* 39392, *Ramaswami* 1473, 1285 and many others, the characters of both *V. articulatum* and *V. nepalense* are present on the same plant, *i.e.*, the lower internodes are wider, thick, tuff and wrinkled and the upper and topmost internodes are narrower, thin, flattened and finely grooved with longitudinal lines. As regards flower cluster and the fruit size, there is no appreciable difference. As such, it becomes practically impossible to distinguish one from the other. Danser also expresses the same opinion on examining a few Peninsular India and Ceylon specimens like *Wight* 1228, *Wight*, Kew distribution No. 1248, *Wallich* 496 and *Bourne* 864. Many more such specimens not seen by Danser and which are exactly like *V. articulatum*, have been examined by the writer. There are also many specimens, such as *Rama Rao* 1581 and Madras Herb. 13142 which show fine and delicate internodes like those of the Assam specimens which are named by Danser as true *V. articulatum*.

There is an interesting specimen collected by Ridley from Garden, Singapore and another from Queensland by Bailey which contain round, 4-angular and also flattened internodes and which appear as more akin to *V. angulatum*. However, as *V. angulatum* has not been so far reported anywhere outside Peninsular India, the specimens may at present be considered as the non-flattened forms of *V. articulatum*.

Danser notes that *V. articulatum* is usually parasitic on members of Loranthaceæ but on the basis of collections from South India, there appears to be no such restriction in the selection of host. This species has been reported by Fischer (1926) to be parasitic on a variety of hosts.

As regards the differentiation between *V. nepalense* and *V. liqui-dambaricolum* Danser points out that the only real difference seems to be in the ripe fruits which are nearly globose in *V. nepalense* and more oblong in *V. liquidambaricolum* and the difference in width of the internodes, the former having broader internodes than the latter species, is not at all a dependable character. Doubting whether *V. nepalense*

and *V. liquidambaricolum* are distinct species or geographical varieties of one species, he finally expresses that he is much inclined to accept the latter supposition because it is remarkable that if the form of the fruit is taken as a criterion, *V. nepalense* in its further characters shows a distinct approach towards *V. liquidambaricolum* as the area of distribution of the latter is gradually approached. As has been pointed out by Danser, Calcutta Herbarium specimens of this group collected from the Himalayan zone, show mixed characters of both the species such as wider and rough internodes and oblong fruits on the same specimen, *i.e.*, *Butler* 27205. In some, for example *Hamilton* (Nepalia in 1802), *Craib*. 341, there is much variety in shape of the fruits from clearly globose to oval and nearly oblong on the same shoot as shown in Fig. 8. Danser, questioning one Hamilton's specimen from Nepal which could not be seen by him in any Herbarium and which was described by D. Don, suggests that it may be *V. nepalense*. The sheet of this specimen quoted above is available in the Calcutta Herbarium. Interestingly enough, this specimen combines the characters of both the species exhibiting wide and rough internodes at the lower part and delicate and narrow internodes at the upper region and oval to oblong fruits all over the specimen. These various specimens mentioned above may be considered as intermediate forms connecting the two species. Further, these plants with oblong fruits which are called as *V. liquidambaricolum* appear to be not restricted to any specific host whereas *V. liquidambaricolum* is said to be mostly parasitic on *Quercus* and *Liquidambar* in China and Formosa. Further, the specimen collected from Formosa shows narrow and slender internodes and typically oblong fruits and such specimens have been reported to be common more to the east towards China where specimens with broader and tough internodes and nearly globose fruits are hardly found any more. All these data give the impression that the Indian *V. articulatum* and the so-called *V. nepalense* with broad and coarse internodes and globose fruits gradually merge into the so-called East Asiatic *V. liquidambaricolum* with narrower and slender internodes and more oblong fruits.

Therefore, it may be concluded that as *V. nepalense* can be merged into *V. articulatum* as they are one and the same species with practically no distinction except the degree of difference in the size of internodes and fruits in accordance with the maturity of plants, the Chinese form *V. liquidambaricolum* may at best be considered as a variety of *V. articulatum* on the basis of distinct oblong fruits.

As regards *V. articulatum* var. *flexuosum* (Gamble) Danser, the writer agrees with Danser in maintaining it as a variety common in Malayan Peninsula. Though Gamble in his 'Revision of Loranthaceæ of the Malayan Peninsula' distinguished this as a distinct species, *V. flexuosum* on the basis of very narrow internodes and small fruits and though the species appears to differ more strikingly from *V. articulatum* at first sight, on critical examination it appears to be a very narrow variety of *V. articulatum*, the narrow forms of which are quite common in Malayan Peninsula. In fact, the specimens collected from the Khasia

Hills (Coll. ? 1014, *G. Mann* 98, *Sharma* 10521, *Kanjilal* 5852), Singapore (Coll. ? 8054) combine both the characters of *V. articulatum* and *V. flexuosum* in the size of internodes and may be considered as inter-mediate forms. Probably, the juvenile forms with branches 2–3 mm. broad as recorded by Santapau (1953) from Khandala (Bombay State) may belong to this group of intermediate forms. If this is possible in such a farther region of Western India, it would be a really interesting record.

A few interesting specimens with very fine internodes have also been collected from Sumatra (*Forbes* 2506), Philippines and North Australia. Though Danser placed these under *V. articulatum* and though Philippine and Australian specimens have been identified as *V. angulatum*, it is very evident that they have striking similarity with the variety *flexuosum* particularly in their fine internodes. Merrill also has noted for one of the Philippine specimens (Species Blanconæ No. 695) that it might prove to be a form of *V. articulatum* Burm.f. with very narrow branches.

As regards *V. nepalense* var. *thelocarpum* Danser which is purely based on the verruculose or warty condition of immature fruits, it is interesting to note that the warty character on the immatured fruits has been consistently present on different specimens collected from different areas like Concan, Canara and Ajmere though the plant resem-bles *V. articulatum* in all other aspects. It is really a point for further consideration whether a stage in the development of fruit may be con-sidered as a character for a variety. Further, a few of the many speci-mens of *V. articulatum* collected from various places in the Bombay State such as *Santapau* 3897, 13·15, 10719 show slight warty condition in their very young fruits, probably on the basis of which Santapau (1953) has merged var. *thelocarpum* into the main species. This echinu-late character found in these specimens is comparatively of much lesser degree than that of the Ajmere and Concan specimens. Even in these Bombay specimens there is considerable variation in the intensity of the development of warts on different young fruits of the same speci-men and there are even some young fruits without warts at all on some of these specimens. In view of these findings, it appears that the Bombay specimens represent the intermediate stages to connect *V. articulatum* proper without warty young fruits with those specimens representing the so-called true variety *thelocarpum* where all the young fruits show definite warty character, which conclusion may lead to the merging of this variety into the species proper. However, on the basis of the available material which may be considered as insufficient, the writer would at present prefer to keep it as a variety of *V. articulatum*.

So, on the basis of the above discussion, the following may be con-sidered as the varieties of *V. articulatum* Burm.

(i) **V. articulatum** var. **flexuosum** (King ex Gamble) Danser in *Blumea*, **4**: 283, 1941; *V. flexuosum* King ex Gamble in *Kew Bull.*, **1913**: 47, 1913.

(Internodes uniformly 2 mm. broad; fruit nearly 2·5 mm. broad.) (Fig. 6).

(ii) **V. articulatum** var. **liquidambaricolum** (Hayata) Seshagiri Rao *nov. var.*; *V. liquidambaricolum* Hayata, *Ic. Pl. Formos*, **5**: 194, 1915; Danser in *Blumea*, **4**: 289, 1941.

(Fruits typically oblong.) (Figs. 7, 8.)

(iii) **V. articulatum** var. **thelocarpum** (Danser) Seshagiri Rao *nov. comb.*; *V. nepalense* var. *thelocarpum* Danser, *loc. cit.*, 289.

(Young fruits distinctly warty.) (Fig. 9.)

FIG. 6. *Viscum articulatum* Burm. var. *flexuosum* (Gamb.) Danser (*Kunstler* 1187).
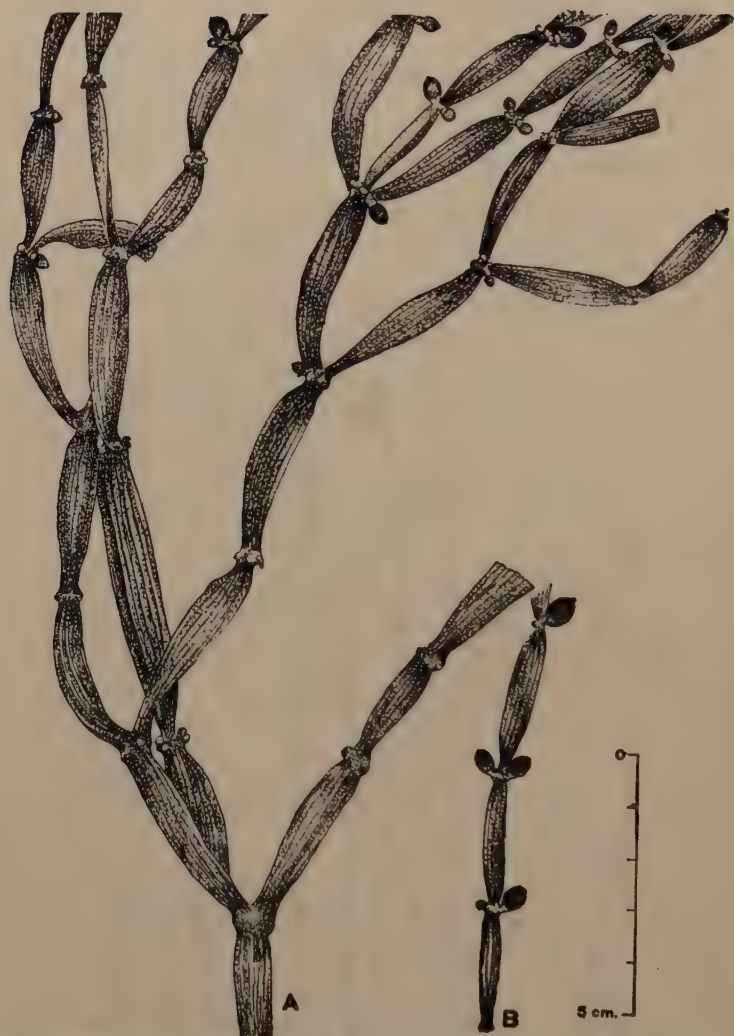
FIG. 7. *Viscum articulatum* Burm. var. *liquidambaricolum* (Hayata) Seshagiri Rao. A. Shoot with oval fruits (*Deka* 23499); B. Small twig with fruits (*Kanjilal* 9517).

As per Danser's differentiation of species, the distribution of *V. articulatum* is limited to South of Brahmaputra River on the North-West side, China on the Eastern side and North Australia on the Sou-thern side, that of *V. nepalense* extends throughout India and Ceylon and as far as Burma and Malaya Peninsula and doubtfully to China and that of *V. liquidambaricolum* is restricted to the Himalayan zone and Assam and to China, Formosa, Indo-China and Java. Now when

Fig. 8. *Viscum articulatum* Burm. var. *liquidambaricolum* (Hayata) Seshagiri Rao. Shoot having round, oval and oblong fruits (*Hamilton* in 1802).

all the three species are merged into one, the distribution of *V. articulatum* may be considered to be very extensive from India with the Himalayas as the Northern limit to as far as China on the Eastern side and North Australia on the Southern side including all the intervening regions like Burma, Malaya Peninsula, Siam, East Indies and Philippines. Peculiarly enough, the distribution of *V. articulatum* var. *flexuosum* hitherto appearing to be restricted to only Malayan Peninsula and that too round about Singapore now extends to Sumatra, North Australia and Philippines though they had been so far sparsely collected. But, the other variety *liquidambaricolum* appears to be distributed from the North-West Himalayas to as far as China and Formosa through Assam. The third variety *thelocarpum* is, however, not well represented

FIG. 9. *Viscum articulatum* Burm. var. *thelocarpum* (Danser) Seshagiri Rao.
A. Shoot with fruits (Ajmere, *Type* specimen); B. Node with warty fruits enlarged.

and appears for the present to be located on the West Coast and Ajmere only (Map 5, A, B, C, D).

Specimens examined

V. articulatum Burm.

> *Wall. Cat.* no. 498 (Tavoy, Burma); 496 B (Permacoir); 496 C (Courtallam, South India); 496 A (South India); 495 A (Mt. Syllet, Assam).

> INDIA: *Bengal, Bihar, Chotanagpur and Orissa:* Pachet Village, *Kurz,* on *Diospyros;* Bihar, 1,000 ft., *Hook. f. and Thomson;* Manbhum, *Bal;* Singhhum, Jorsa 500 ft., *Clarke* 34398, plentiful on

Diospyros; Hotsprings, Boraro River, *Prain*; Chakulia, Dhal-
bhum, *Gamble* 9210; Mohulpahari, Rampur Hat, E.I.R.,
Coll. ? 13, 26th May 1903; Kumandi Reserve, Palamaw
Chotanagpur, *Gamble* 8810; Partab, Puri Dist., Orissa, *Lace*
2510.

Assam: Khasia, Coll. ?; Mt. Khasia 3–5,000 ft., *Hook. f. and
Thomson*; Khasia, Visci Sh. 1014, Pendulous from trees;
Khasi Hills and Bhramhaputra plains, *Herb. Kurz*; Jawai,
4,000 ft., Khasi Hills, *Robertson*, Nov. 1890; Khasia Hills
5,000 ft., *Mann.* 835, May 1878; Sirohifurer 6,000 ft., Manipur,
Watt, 6484; Singoih 6,800 ft., Daphla Hills, *Lister* 316;
*Khasia Hills 3–4,000 ft., Forest Herb. *Mann.* 98, June 1877;
*Nongbri forest, K. & J. Hills, *Kanjilal* 5852, 19–9–1915 (used
by countrymen as specific for pains); *Peak forest, K. & J.
Hills, *Sharma* 10521, 16–1–1933 (*Forms intermediate between
V. articulatum and *V. articulatum* var. *flexuosum* from Shillong
Herb.) (other Assam specimens probably approach var.
liquidambaricolum).

E. Himalaya: Darjeeling 7,000 ft., *Gamble* 370 C, on Mapple;
Sikkim 2–5,000 ft., *Hooker*, Herb. H. f. & T.T.; Lachung
Valley, Sikkim 7,000 ft., *Gammie* 1203.

C. Himalaya: Nepal, *Wallich* ex Herb. Brown.

N.W. Himalaya: Bhimtal 4,000 ft., *Meebold* 4059; Loc. N.-W.
India, Herb. *Royle;* N.-W. Frontier, Loc. ? *King*, Sept. 1868.

Upper Gangetic Plain: Nepal Frontier, *Inayat* 23818.

C. India: Sagar and Mathura near Heerapoor, Coll. ? 422/1;
Padunarlu C.P., *Duthie* 10549; Chanda District, C.P., *Duthie*
9727, on *Diospyros*; Saugor, C.P., Coll. ?; Central Provinces,
Loc. ?, *Hole* 98.

Peninsular India: Khaliyaguda 1,000 ft., Ganjam Dist., *Gamble*
14096; Boragudem, Rampa country, Godavari Dist., *Narayan-
swami* 281, on *Zizyphus;* Chodavaram, Godavari Dist., *Rama-
swami* 1473; Murremkonda, Nellore Dist., *Ramaswami* 1285;
Balapadugu 3,000 ft., Coimbatore Dist., *Fischer* 701; Bailur
3,600 ft., Coimbatore Dist., *Fischer;* Coonoor Ghat, 1,850 ft.
Nilgiri Dist., *Fischer* 2078; Culhatty 4,000 ft., Nilgiris, *Clarke*
11266; Mt. Nilgiri and Coorg, Herb. *Hook. f. and Thomson*;
Kodaikanal Ghat, Pulney Dist., *Bourne* 1164; Pen. Ind. Orien.,
Kew Distr. No. 1248, Herb. *Wight*; Mahendragiri, Tinnevelly
Dist., Madras Herb. no. 13142; Mundandurai to Kannikatti
2,000 ft., Tinnevelly Dist., *Hooper and Ramaswami* 39392; Near
Mekarai, Travancore State, *Calder and Ramaswami* 564;
Makara, Travancore, *Rama Rao* 1581; Arianhami 1,000 ft.,
Travancore, *Bourdillon* 693; Attapadi Valley, near Gopivari
1,600 ft., South Malabar, *Fischer* 1764; Kumsi 2–3,000 ft.,

Mysore State, *Meebold* 10152; Dwitiope, North Kanara, *Talbot*, 1142, on *Diospyros melanoxylon;* *Monkey Hill, flat at foot of Behram's plateau, Khandala, *Santapau* 4457, 3897 (on *Terminalia* sp., young fruits almost achinate); Monkey Hill plateau, Khandala, *Santapau* 8892, 8893; Pattanmal plateau, near reversing station, *Santapau* 4341, 4342 (on *Terminalia tomentosa*); Khandala, *Santapau* 67 A (on *Eugenia jambolana*), 10719; Top of Behram's plateau, Khandala, *Santapau* 9990, 9991, 9992, 9993; Borivikavery caves, Salsette, *Santapau* 2314 (on *Grewia tiliæfolia*); Moroshi, Salsette islands, *Santapau* 1799 (on *Grewia tiliæfolia*), *d'Almeida* 1627, 1628; Salsette islands, *Santapau* 13·39 (on *Grewia* sp.) Makal caves, Salsette, *Santapau* 6763; Makal caves, Andheri, *Santapau* 679, 12822 (on *Grewia tiliæfolia*); Elephanta, *Santapau* 1323, 1324, 1325 (on *Grewia*); Nhava island, Bombay, *Santapau* 1357 (on *Grewia* sp.); Caves one mile North of Andheri, Kurtu rol., Salsette, *Santapau* 547 (host—a leafless tree, possibly teak); Elephanta island, *Santapau* 17530 (very abundant on *Grewia tiliæfolia*); Mumbra, Thana, *Santapau* 8136; Trombay, *Acland* 1068, 1069; Parsik Hill 1,000 ft., *Acland* 1067; Uran, *Santapau* 13·15 (on *Grewia*); Unai, South to S.-E. Hills, Dangs, *Santapau* 17173 (on *Diospyros melanoxylon* in dense forest); Kileshwar, Kathiadijar, Navanagar State, *Santapau* 7911; Palachury, Ghogri, C.P., *Bole* 43 (on *Albizzia lebbek*); Chauri, Chindwara Dist., C.P., *Bole* 79 (on *Pallas* ?) (*Specimens started from this mark are from Blatter Herbarium, St. Xavier's College, Bombay).

CEYLON: Loc. ?, C.P. 479.

BURMA: Maul Main, *Falconer*, 19th March 1849; Rangoon, Coll. ?, March 1854; Chin Hills, Upper Burma, *C.R. Dun* 107; Ruby Mines, Upper Burma, *Huk* 171; Pegu, *Kurz* 1978; Yomah, Pegu, *Kurz* 377; Tongla, Upper Burma, *Huk*, 2; Palse 4,000 ft. Chin Hill, Minbu dist., *Mokim* 1150.

MALAYAN PENINSULA: Simpang, Perak, *Wray Jr.* 2023; *Chau Chu Kang, Singapore, Coll. ? 8054; Mandai Forest, Singapore, *Burkill*, 277; *Fresh-water Isles, Singapore, Coll. ?; *Penang 2,000–2,500 ft. *Kunstler* 1686; Malacca, Kew Distr. No. 697, Herb. *Main-gay;* Penang Hill, Scott s.n. on *Loranthus pentandrus;* Larut, Perak, within 300 ft., *King's Coll.* 4191; Malacca, Harvey s.n.; Garden, Singapore, *Ridley*, Aug. 1889. (Sheets marked with * show very fine internodes intermediate between *V. articulatum* and *V. articulatum* var. *flexuosum*.)

MALAYAN ARCHIPELAGO: Java, *Winckel* 1841 B; Usukan to Khota balud, North Borneo, *Clemens* 9755; Buitenzorg, Java, *Dihen* s.n.; Buitenzorg, Java, *Kurz* ? 176; Java, Herb. Horsfield.

SIAM: Chiengmai, *Kerr* 1301; Siam, *Jeysmanu* s.n., Herb. Kurz.

PHILIPPINES: San Francisco del Monte, Rizal Prov., Luzon, *Merril* 792; Mt. Pulog, Benguet Prov., Luzon, Forestry Bureau No. 16243; Todaya, Davao Dist.; Mindanao island, Elmer Distr. No. 11963; Luzon, *Loher* 4482; on *Erythrina caffra*.

CHINA: Hupeh Prov., Central China, *Henry* 3206 (may be var. *liquidambaricolum* but the fruits are not present).

AUSTRALIA: Nerungcreets, South Queensland, *Bailey*.

(i) **V. articulatum** Burm. var. **flexuosum** (King ex Gamble) Danser.

MALAYA PENINSULA: Tomghon, Singapore, *Ridley* 6018; Botanic Garden, Singapore, *Ridley* 8902; Singapore Island, *Kings Coll.* 1187.

MALAYAN ARCHIPELAGO: Sumatra, *Forbes* 2506.

PHILIPPINES: Burgos, Ilocos Norte Prov., Luzon, Coll. *Ramos*, Bureau of Science No. 27255; Calumpit, Bulaccan Prov., Luzon, *Merrill* 695 (Merrill writes that these may prove to be merely a form of *V. articulatum* Burm. with very narrow branchlets. This form is rare in the Philippines and has only been found in 2 or 3 localities).

AUSTRALIA: South Coen River, Queensland, Coll ?, Von Mueller, Phytologic Museum of Melbourne; Sources of South Coen River, Queensland, Johnson s.n. in 1891, Von Mueller, Phytologic Museum of Melbourne; Belluiden River, range tropical, Queensland, *Bailey;* Tambourine, Queensland, *Scortechini*.

(ii) **V. articulatum** Burm. var. **liquidambaricolum** (Hayata) Seshagiri Rao *nov. comb.*

INDIA: *Assam:* Konoma, Naga Hills, *Watt* 11750; Pulmalodge, Naga Hills, *Prain* s.n.; Kigonma edge 7,500 ft., Naga Hills, *Clarke* 41888; Mawphlang 5,600 ft., Khasia Hills, *Clarke* 44243; *Lao-soh mynkhar, K. & J Hills, *Kanjilal* 5935, 28–9–1915 (on *Castanopsis hystrix*, Khasia name——Tyrphin); Sohrarim, K. & J. Hills, *Kanjilal* 9517, 19–9–1931; *Deka* 20347, 1–5–1941 (on *Quercus dealbata*); Lawlyngdoh, K. & J. Hills, *Deka* 30–6–1937, *Deka* 23499, 9–6–1956 (on *Quercus dealbata*, stem yellowish-green, young fruit green, ripe fruit yellowish-green). Naga Hills, *Bor.* 17671; Kanglatunglei, Manipur, *De*, 22–2–1939 (*Specimens beginning from this asterisk mark are from Shillong Herbarium); +Sepramaina 2,800 ft., Manipur, *Deb* 1381 (on *Quercus semiserrata*, tender shoot with oblong fruits, 20–12–1953); Loc. ?, Manipur, *Deb* 809 (on *Quercus serrata* var. *roxburghii*); *Deb* 929 (on *Quercus serrata*, young shoots, no fruits) (+Specimens beginning from this mark are from Deb, probably deposited in the D.M. College Herb., Imphal. All form new records for Manipur Hills).

E. *Himalaya:* Birch Hill 7,000 ft., Sikkim Himalaya, *King* 5102;
Munsong 4,000 ft., Sikkim, *Craib* 341 (fruits of various shapes
—round, oval and oblong).

C. *Himalaya:* Nepalia, *Hamilton* in 1802.

N.W. *Himalaya:* Mussorie, *Mackinnon* s.n. (on *Curpinus
viminea*); Kullu, *Brandis* 3474; Glen 6,000 ft., Simla, *Gamble*
6233 F; Ranikhet 6,000 ft., Kumaon, *Butler* 27205, Coll.
Inayatkhan (on *Loranthus vistitus* which is on *Quercus incana*);
Simla 8,000 ft., *Meebold* 5096.

FORMOSA: Bankinsing, *Henry* 59.

(iii) **V. articulatum** Burm. var. **thelocarpum** (Danser) Seshagiri
Rao *nov. comb.*

INDIA: *Peninsular India:* Oshele, Canara, *Ritchie* 333; Malawar,
Concan, etc., Herb. Ind. Or. Hook. f. & Thom., *Stocks, Law,*
etc. *C. India:* Ajmere, Coll. ? (Typus II, Danser s.n., loan
from Dehra Dun Herb.).

5. **Viscum angulatum** Heyne ex A.P. de Candolle, *Prodr.,* **4**:
283, 1830; Wight and Arnott, *Prodr. Fl. Pen. Ind. Or.,* 380,
1834; Dalzell and Gibson, *Bombay Fl.,* 110, 1861; Hooker f.,
Fl. Br. Ind., **5**: 225, 1886; Engler in *Engl. and Pr. Nat.
Pflanzenfam.,* **3**: 195, 1889 pro parte; Gamble, *Ind. Timb.,*
584, 1902; Brandis, *Ind. Trees,* 552, 1906; Cooke, *Fl. Bombay,*
2: 553, 1906; Talbot, *For. Fl. Bombay,* **2**: 422, 481, 1911;
Gamble, *Fl. Madras,* **7**: 1257, 1259, 1925; Fischer in
Rec. Bot. Surv. Ind., **11**: 181, 1926; Engler and Krause in
Engl. Nat. Pflanzenfam. (ed. 2), **16 b**, 203, 1935; Danser in
Blumea, **4**: 292, 1941; Santapau in *Rec. Bot. Surv. Ind.,*
16: 267, 1953; Santapau, *Plants of Sugurashtra,* 34, 1953;
V. ramosissimum Wight, *Ic. Pl.,* **3**: t. 1017 tantum, 1845.

Plants monœcious. *Stems* slender, somewhat hanging, branches
numerous, decussate or more than two at each node, lower internodes
terete or with two opposite ribs, 2–5 cm. long, up to 4 mm. in diameter,
usually less thick, internodes of middle region of plant distinctly 4-angular,
sometimes with less prominent ribs in between the four main ones,
hardly flattened towards the apical part, apical internodes 1–4 cm.
long, 1–2 mm. in diameter, tender ones somewhat flattened towards
their apices. *Leaves* scaly, almost invisible, 0·5 mm. long or even
less, also small scales (prophylls) at bases of branches. *Inflorescences*
usually sessile, lateral, rarely terminal, very slightly peduncled, 1–3
flowered, if one-flowered with one female flower subtended by two bracts
connate at base, if 3-flowered one central female flower as above and
two lateral male flowers usually in the axils of another pair of bracts
decussate to the upper connate ones; sometimes two more 1–3 flowered
inflorescences one on either side of the first one; very rarely further
branches of inflorescence with crowded flowers, 2–2·5 mm. long and
broad. *Fruits* nearly globose at maturity, up to 4 mm. in diameter,

usually surrounded at base by two depressed bracteal cups. (Description from specimens in the Calcutta Herbarium and partly adapted from Danser, *loc. cit.*) (Fig. 10).
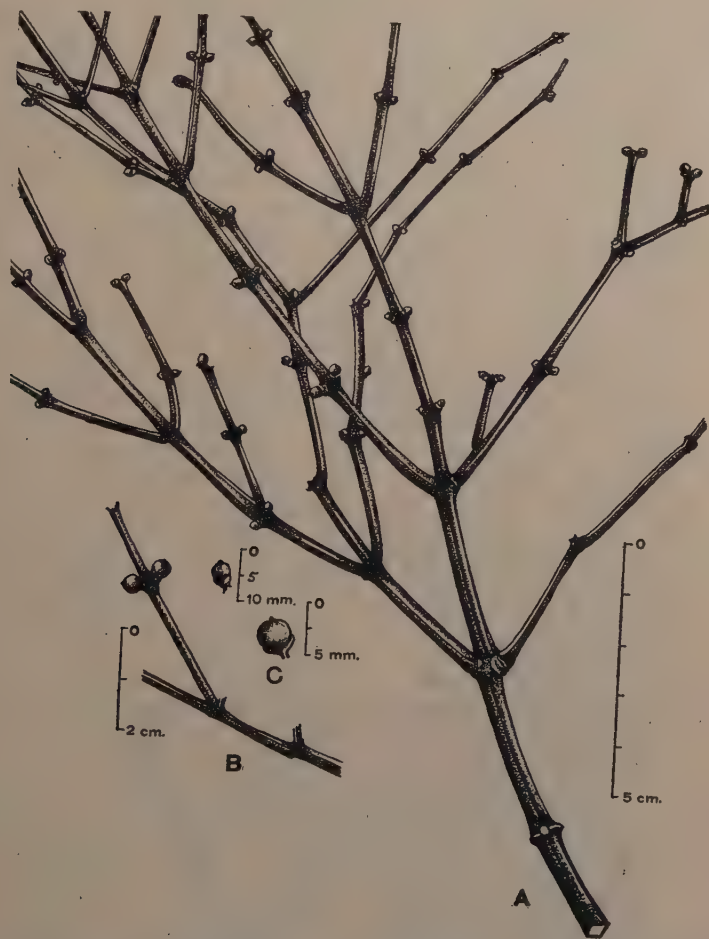

FIG. 10. *Viscum angulatum* Heyne ex de Cand. A. Shoot with very young fruits (*Wight* 52); B. Small twig with fruits: C. Fruits enlarged.

Viscum angulatum with its characteristic quadrangular internodes of the medium part of the plant is sharply delimited from *V. articulatum* and its varieties, though in the structure of inflorescence, flower and fruit, there is practically no difference at all.

With the data available, the distribution of this species in India appears to be very restricted to the Peninsular India and that too only in the far-south region below Madras on the Eastern side and from Saurashtra down the Western Ghats on the Western side (Map 3 A).

Specimens examined

> *Wall. Catno.* Herb. Wight 497 B (no locality).

INDIA: *Peninsular India :* Loc. ? *Ritchie* 334; Flora of Bombay, College of Science, Poona; Tegur, Dharwar—Belgaum Road about 2,000 ft., *Sedgwick* 5508; loc. ? *Herb. Wight* 52; Palamalai 3,500 ft., *Saulieres* 437, 734; Palamalai 3,000 ft., *Munch* 101; Near Huginium 3,400 ft., Coimbatore Dist., *Fischer* 175; Culhatty 4,000 ft., Nilgiris, *Clarke* 11312 B & C Sigur Ghat 4,000 ft. Nilgiris Dist., *Gamble* 14508; Mt. Nilgiri and Kurg, *Thomson*, Herb. Hook. f. & Thom.; Middle Pulneys 4,000 ft., *Rodriguez* 2065; Seegor 3,000 ft., Mysore, *Clarke* 11254 (3 sheets); Satavari 3,000 ft., Kadur Dist., Mysore, *Talbot* s.n.; Tambacheri ghat, Wynad, *Barbar* 7,400. *Khandala, *Santapau* 13·6 H (on Jambul), 13·11, 13·20 (on *Oleadioica*), 24484, 24538, 24539; Echo plateau top, Khandala, *Santapau* 4214 (on *Carissa carandas*); Talao, Khandala, *Santapau* 8625; Echo point, Khandala, *Santapau* 4527, 28346 (on *Flacourtia*); Bhoma Hill, Khandala, *Santapau* 6959; Con. Home.—Khandala Hotel, Khandala, *Santapau* 1651 (on *Olea dioica*); Khandala, *Santapau* 659 (on *Olea dioica* together with *Loranthus cuneatus*); Khandala, *Santapau* 567 (on *Eugenia jambolana*); Paradise Hill and plateau, Purandhar, *Santapau* 6171, 6172; Paradise plateau, Purandhar, *Santapau* 8258; Round Purandhar Fort, Purandhar Hill, Poona Dist., *Santapau* 5682; Lingmala, Mahableswar, *Santapau* 12483 (on *Flacourtia*), *Bole* 378; Loc. ? *Patel* (Dr. D. K. Patel's Herb.).

6. **Viscum ramosissimum** Wight & Arnott, *Prodr. Fl. Pen. Ind. Or.*, 380, 1834; Wight, *Ic. Pl.*, **3**: 13, 1845 (excl. t. 1017); Hooker f., *Fl. Br. Ind.*, **5**: 225, 1886; Engler in *Engl. and Pr. Nat. Pflanzenfam.*, **3**: 195, 1889 and 140, 1897; Trimen, *Fl. Ceylon*, **3**: 472, 1895; Gamble, *Ind. Timb.*, 584, 1902; Brandis, *Ind. Trees*, 552, 1906; Cooke, *Fl. Bombay*, **2**: 554, 1906; Gamble, *Fl. Madras*, **7**: 1257 and 1258, 1925; Fischer in *Rec. Bot. Surv. Ind.*, **11**: 161, 1926; Engler and Krause in *Engl. Nat. Pflanzenfam.* (ed. 2), **16 b**: 201, 1936; Danser in *Blumea*, **4**: 294, 1941; *Aspidixia ramosissima* Van Tieghem in *Bull. Soc. Bot. Fr.*, **43**: 193, 1896.

Plants monœcious. *Stems* slender, branches numerous, decussate or more than two at each node, lower internodes stout, smooth and distinctly terete or sometimes longitudinally grooved and round, usually 3–5 cm. long rarely even longer in extreme forms, up to 5 mm. in diameter, usually less thick towards apex, apical internodes 4–15 mm. long, 1–2 mm. in diameter, younger ones somewhat flattened towards their apices. *Leaves* absent on Herbarium specimens; the only leaf of *Wallich Cat.* 6876, according to Danser (*loc. cit.*), lanceolate-obovate, attenuate towards the base but not petiolate, apex rotund, 22 mm.

long, 5·5 mm. broad, thick, with 3 hardly prominent but distinct longitudinal nerves. *Inflorescences* usually lateral and same as *V. angulatum*. *Fruits* small, sub-globose in young stage, mature fruits not available on Herbarium specimens. (Description from specimens of the Calcutta Herbarium and partly adapted from Danser, *loc. cit.*) (Fig. 11).

FIG. 11. *Viscum ramosissimum* Wt. & Arn. A. Apical part of shoot (*Gamble* 12115); B. Lower internode (Grooved); C. Lower internodes (Long and terete— *Wall. cat.* 6876).

V. ramosissimum resembles *V. angulatum* very closely in many characters except the shape of the internodes which are terete and sometimes longitudinally grooved in the former and quadrangular in the latter, both however having somewhat flattened young internodes

at the tip.   Though Wight and Arnott mention that the species some-times possesses a few leaves, the herbarium specimens examined are entirely leafless.   Danser reports that only the specimen *Wallich Cat.* no. 6876 in the Kew Herbarium bears one leaf and opposite to this, a leaf scar.   There is much variation in the size of the internodes and specimens like Herb. Wight, *Wallich Cat.* no. 6876 and Ex. *Herb. Wight* 53, exhibit extreme form with closely branched and very fine and long internodes.

Strangely enough, there is a specimen collected by J. Horne (*Horne* 894) in 1877–78 from Fiji islands which matches very well with *Wallich Cat.* no. 6876 and is certainly appearing to be *V. ramosissimum.*   It is rather strange how this species which has been so far reported only from South India, can occur in such a remote island without any trace of it in the neighbouring zones.   However, the writer doubts whether any wrong label was attached to this specimen.

Though *V. ramosissimum* was described as early as 1834, the plant is inadequately described and hence a thorough examination of this species in the living condition is worth studying.

This species also has a very restricted distribution mostly being confined to South India that too, only in the districts of Chittore, Coimba-tore, Nilgiris, Tinnevelly and also in Ceylon.   The record of this species from Fiji islands, of course, if the label is correct, creates peculiar trend in the distribution of the species.   Hence, more evidence on this subject is worth waiting for (Map 4 B).

Specimens examined

Wall. Cat. no. 6876 (Gingee Hill); *Herb. Wight* 6876 B.

INDIA: *Peninsular India:* Palmaner 2,500 ft., Chittoor Dist., *Fischer* 4313; Attumali 4,500 ft., Anamalai Hills, *Fischer* 3418; Palamalai, Coimbatore Dist., *Fischer* 24; Sholampalaiyam 1,400 ft., Coimbatore Dist., *Fischer* 1734; Black bridge 6,000 ft., Nilgiri Dist., *Gamble* 12115; Coonoor 6,000 ft., Nilgiris Dist., *Gamble* 11693; *loc.?* Ex. *Herb. Wight* 53.

And also probably

FIJI ISLANDS: Fiji islands, *J. Horne* 894, 1877–78, Recd. March 1879.

7. **Viscum loranthi** Elmer, *Leaflets Philipp. Bot.,* **8**: 3089, 1919; Merrill, *Enum. Phil. Fl. Pl.,* **2**: 113, 1923; Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **11**: 464, t. 27 *b, c,* 1931; in *Philipp. Jour. Sc.,* **58**: 142, 1935; in *Blumea,* **4**: 295, 1941; *Viscum* sp., Osmaston, *For. Fl. Kumaon,* 465, 1927; *Viscum osmastonii* Raizada in *Ind. For.,* **60**: 537, t.55, 1934.

Plants monœcious. *Stems* slightly rigid, lower portion much branched, branches decussate; lower internodes somewhat slightly

longitudinally grooved, terete, 2–2·5 cm. long, 3–4 mm. in diameter, internodes becoming shorter gradually towards the apices, the top-most internode about 5–6 mm. only. *Leaves* absent. *Inflorescences* lateral forming a cluster of cymes at the apex of each internode just below the node, cyme 3-flowered, probably sessile, central female flower, lateral ones male, subsequent cymes on either side of the first cyme, later female flowers becoming prominent and closely adpressed together around the node. *Female flowers* ovate, 1 mm. long, tepals four, ovate, acute, ovary slightly verruculose, style very short with a small nipple-shaped stigma. *Male flowers* ovate, $\frac{3}{4}$ mm. long, tepals four nearly of same size, acute. *Fruits* immature ones subglobose, up to 4 mm. long, up to 3 mm. in diameter, slightly verruculose, four tepals persistent as crown (Fig. 12).
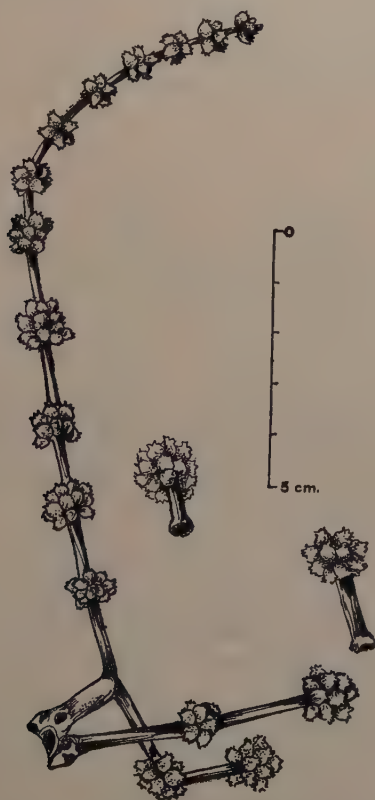
Fig. 12. *Viscum loranthi* Elmer. Shoot with fruits (*Osmoston* 1536).

The numerous buds and bracts in the inflorescences are very densely crowded and hence the morphological arrangement of bracts appears to be much disturbed by reciprocal pressure. Such an arrange-ment can be studied only from fresh specimens representing different stages in the development of inflorescence.

The writer agrees with Danser in reducing *V. osmastonii* Raizada to *V. loranthi* Elmer. This species is characteristically parasitic on closely allied genera of Loranthaceæ and Osmoston's specimens collected from the North-West Himalaya were found parasitic on *Taxillus vestitus* which in turn was parasitic on *Quercus dilatata*. The species has been reported to be parasitic also on *Scurrula cordifolia*, *Scurrula pulverulenta* and *Dendrophthœ falcata*, all of allied genera.

In India, this species has so far been reported only from the Western Himalayas. Now, it has been newly recorded from the Manipur hills also. It also occurs in Yunnan, Luzon and Sumatra. The presumption of Danser that "the discovery of *V. loranthi* in the Himalaya and Yunnan makes a larger distribution in the mountains of South-Eastern Asia probable", has been further strengthened now by the collection of this species by Deb from the Manipur Hills. So it is quite possible that this species may occur in the Eastern Himalayas, *North-East Frontier Agency and Burma also, so as to establish a continuity in the line of distribution (Map 3 C).

Specimens examined

INDIA: *Western Himalaya:* loc.? 2,500 ft., Dehra Dun Dist., *Mackinnon* 23028; Nalia Reserve 6,000 ft., East Almora Division, *Osmoston* 1536 (parasitic on *Loranthus vestitus*, which was parasitic on *Quercus dilatata Type* of *Viscum osmastonii* Raizada) (Dehra Dun Herb.).

Assam : Kangpokpi 3,400 ft., Manipur, *Deb* 1714, on 10–2–1954 on *Quercus ?* (*New Record*, D.M. College Herb., Imphal).

Assam : Kangpokpi 3,400 ft., Manipur, *Deb* 1714, on 10–2–1954 on *Quercus* (*New Record*, D.M. College Herb., Imphal).

PHILIPPINE ISLANDS: Los Banos (Mt. Maquiling), Prov. of Laguva, Luzon, Elmer Distr. No. 17777.

8. **Viscum ovalifolium** A.P. de Candolle, *Prodr.*, **4**: 278, 1830; Hook. f. in *Fl. Br. Ind.*, **5**: 225, 1886 pro parte; Gamble, *Ind. Timbers*, 584, 1902 pro parte; Brandis, *Ind. Trees*, 552, 1906 pro parte; Danser in *Blumea*, **4**: 296, 1941; *V. orientale* Bentham in *Hooker Lond. Jour. Bot.*, **2**: 222, 1843; Brandis, *For. Fl. N.W. Cent. Ind.*, 393, 1874 pro parte; Brandis, *Ind. Trees*, 552, 1906 pro parte; Gamble in *Jour. As. Soc. Bengal*, **75** (2): 386, 1914 (cum var. *ovalifolio*); Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **11**: 1931 pro parte; *V. ovalifolium* Danser in *Bull. Jard. Bot.*

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* Fruiting specimens of *Viscum* species, closely resembling *Viscum loranthi* but rather appearing to be different, have been collected by the writer in November 1955 from the hills (6,000 ft.) above Apatanang Valley surrounding Zero, Headquarters of the Subansari Division of North-East Frontier Agency. They could not be matched with any available material at the Calcutta Herbarium. The species is parasitic on *Taxillus vestitus* which in turn is parasitic on another tree (unidentified).

Buitenzorg, (ser. 3) **16** (1): 48, 1938 pro parte; in *Blumea*, **3** (1): 34, 58, t.1, 1938 pro parte; in *Blumea*, **3** (3): 401, 1940 pro parte; *V. monoicum* Griffith, *Not. Pl. As.*, **4**: 637, 1854; *Ic. Pl. As.*, **4**: 631, 1854.

Plants diœcious. *Stems* somewhat slender, strongly branched, entirely glabrous, internodes terete, grooved or not, often somewhat flattened towards the apex, always more or less swollen at the nodes, those bearing full-grown leaves 3–6 mm. in diameter. *Leaves* opposite, lanceolate or ovate or oblong or slightly obovate, apex obtuse or somewhat acute, margin entire, coriaceous, dull on both sides, sometimes inequilateral, usually gradually attenuate towards base tapering into a very short petiole-like structure, 5–9 cm. long, 2–3·5 cm. broad, usually with 3 or 5 longitudinal nerves, more clear on upper side. *Inflorescences* usually lateral, at first single, sessile or shortly peduncled 3-flowered cyme with middle female and lateral male flowers, later many similar cymes on either side of the first one around the node, most of them usually lacking lateral male flowers, thereby developing a cluster of female flowers with male ones here and there; flowers in a navicular cup formed of 2 connate bracts, about 2 mm. long. *Female flower* oblong, 1·5–2 mm. long, tepals 4 short, triangular. *Male flowers* somewhat flattened by pressure, up to 1 mm. long, tepals 4, triangular. *Fruits* roundish-ellipsoidal, somewhat contracted at base, distinctly warty till almost ripeness, 5·6 mm. long, 4 mm. in diameter, crowned by slightly enlarged conical style. [Description from the Calcutta Herbarium specimens and partly adapted from Danser (1938).] (Fig. 13.)

Viscum ovalifolium has always been called *Viscum orientale* by all botanists writing on the Visca of Malayan Peninsula and Malayan Archipelago. By critical examination of Willdenow's type specimens of *V. orientale* by Danser, this point of confusion has been clarified. Willdenow's plant bears in each bracteal cup, 3–5 flowers of which probably always more than one, and usually 3, are female, whereas in *V. ovalifolium*, the inflorescence in the beginning bears 3 flowered cyme of which the middle flower is female and the lateral flowers male. Further, in *V. ovalifolium* the fruits with the exception of very young and entirely ripe ones, are warty whereas in *V. orientale*, the fruits are smooth and dull by minute granules but not at all warty.

V. ovalifolium was described by de Candolle (1830) under two names, *V. ovalifolium* and *V. obtusatum*. These two were later united by Hooker (1886) under *V. ovalifolium* and hence this name only is considered as valid.

In certain specimens from Tenasserim and Malaya, the leaves are unusually small and slightly curved indicating a variety of *V. ovalifolium* but the presence of such small leaves along with typical large leaves on same shoot of some other specimens, removes the possibility of formation of a variety. The Assam specimens collected by Deb are with young flower buds, presenting a characteristic inflorescence structure (*Gallatly* from Assam, *Deb* from Manipur hills).

FIG. 13. *Viscum ovalifolium* A. P. de Cand. A. Shoot with fruits (*Gallatly* 469); B. Warty fruit enlarged.

The species is now for the first time recorded from Assam, which also forms a new record for India. By this, it appears to have a very characteristic and continuous area of distribution. It is commonly found in the Malayan Peninsula, the East Indies and the Philippines and reaches its Eastern limit as far as West New Guinea, its North-Western limit up to Assam through Indo-China, Siam and Burma. In China it appears to be restricted to Hainan and Hongkong and has not been so far recorded in Formosa. The recent collections by Deb (*Deb* 664, 1499, 1712) provide an interesting additional information that this species grows even at higher altitudes as far as 6,000 ft. in the Manipur hills of Assam (Map 1 A).

Specimens examined

Wall. Cat. no. 489, Penang (*co-type* of *Viscum ovalifolium*).

INDIA : *Assam:* loc. ? Assam, *Gallatly* 469 on 3–3–1877 (*new record*);
Koupro Hill 6,000 ft., Manipur, *Deb* 1499 on 19–12–1953;
Kangpokpi 3,400 ft., Manipur, *Deb* 1712 on 10–2–1954,
on *Quercus;* Tengapole 6,000 ft., near Manipur towards
Burma border, *Deb* 664, on 21–1–1953; Maram 6,000 ft.,
Manipur, *Deb* no. ? (All Manipur specimens beginning with
asterisk mark are new records and are probably deposited in
D.M. College Herb., Imphal.)

BURMA : Laikaw, Southern Shan State, Upper Burma, *Abdul
Khalil;* Mergui, Tenasserim, *Meebold* 14317.

MALAY PENINSULA : Malacca, *Griffith*, Kew Distr., no. 2739, 2740;
Penang Hill, Pulau, Penang, *Ridley* 9373; L.W. Rest House,
Perak, *Scortechini* 732; Lower Camp, Gunong Batu Pateh,
Perak, *Wray Jr.*, 1074; Palau, Jellam, Pahang, *Ridley* 2250;
Green, Jurong, Singapore, *Ridley* 1827; Merleman, Malacca,
Derry 195; Chan Chu Kang, Singapore, *Ridley* 6816; Garden,
Singapore, *Ridley* 10369; on *Ficus;* Bukit Madaida, Singapore,
Ridley 3777.

MALAYAN ARCHIPELAGO : Sarawak, near Kuching, Borneo, *Havi-
land and Hose* 3092.

SIAM : Kohchang, *Schmidt* 139.

PHILIPPINES : Antipolo, Rizal province, Luzon, *Merrill*, Sp.
Blancoanæ no. 888; Los Banos (Mount Maquiling), Laguna
Prov., Luzon, *Elmer* Dist. no. 17916 and 17798.

CHINA : Hainon, *Henry* 8420.

9. **Viscum wrayi** Gamble in *Kew Bull.*, **1913**: 47, 1913; in
Jour. As. Soc. Beng., **75**: 387, 1914; Ridley, *Fl. Mal. Pen.*, **3**:
164, 1924; Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3),
11: 470, 1931; in *Blumea*, **4**: 297, 1941.

Plants monœcious. *Stems* strongly and densely branched, entirely
glabrous, each internode somewhat terete at base, gradually flattened
towards the apex, up to twice as broad as the base just below the node
or sometimes slightly more 2–3 cm. long, 2–3 mm. thick at base, some-
times slightly wrinkled. *Leaves* opposite, roundish-obovate to spa-
thulate, apex rotund, margin entire, coriaceous, smooth and dull, gra-
dually attenuate towards base, rarely contracted into a very short petiole-
like structure, 3·5–5 cm. long, rarely up to 6 cm., 1·5–2 cm. broad,
rarely up to 3 cm., usually 3-nerved, sometimes up to 7 nerves, indis-
tinctly visible. *Inflorescences* usually lateral, at first single in axils,
sometimes later up to many, usually 3 flowers in a small navicular cup
formed of two bracts on a short peduncle, the middle female, the lateral
male. *Female flower* oblong, about 2 mm. long. *Male flower* smaller,
somewhat compressed. *Fruits* globose, contracted at base forming
2–3 mm. long stalk, distinctly smooth, 6–7 mm. long excluding stalk,
4–6 mm. in diameter, crowned by prominent tepal-bearing margin and

slightly enlarged conical style. [Description from the specimens of the Calcutta Herbarium and partly adapted from Danser (1931).] (Fig. 14.)

FIG. 14. *Viscum wrayi* Gamble. A. Shoot with fruits (*Wray jr.* 1111); B. Node with fruits; C & D. Young and mature fruits enlarged.

This is a good species and can be readily distinguished from all its allied species by means of the internodes gradually flattened towards the apex and by the nearly obovate leaves with perfectly round apex and smooth and indistinctly veined surface, normally developed at almost all the nodes, by the stalked fruits and by the central female flower of the triads devoid of its own bracteal cup.

This species appears to have a very restricted distribution only in Malay Peninsula and Southern Borneo (Map 1 B).

Specimens examined

MALAY PENINSULA: Lower camp, Gunong, Batu Pateh, *Wray Jr.*, 1111 (*co-types* of *Viscum wrayi* King); 13½ mile Mawai-Jemulong Road, Johore, low alt., *Corner*, Singapore field no. 28992, on *Gomphia corymbosa*; Kedah Peak, *Ridley* 5847.

10. **Viscum acaciæ** Danser in *Blumea*, **4**: 298, t.1. 1941.

Plants monœcious. *Stems* tender, wiry, branching dichotomous nearly at all nodes at the base, somewhat less towards the apices, branches usually opposite, rarely here and there single, adventitious; lower internodes slender, mostly smooth or somewhat longitudinally grooved, terete, not flattened at any region, 3–7 cm. long, 3–1 mm. in diameter in the central part, slightly compressed and nearly 5 mm. wide at nodes, internodes towards apices gradually more delicate, short, not grooved, 2–4 cm. long, 0·8 mm. in diameter, at nodes 2 mm. wide. *Leaves* lanceolate or sub-spathulate to spathulate, base of the leaf partly tapering into petiole of 2–5 mm. long, usually 3·5–7 cm. long, 7–20 mm. broad, rotund, coriaceous with 3 nearly distinct longitudinal nerves. *Inflorescences* single and terminal or a few lateral in the axils of opposite leaves, cyme 3-flowered, peduncled, central flower female, lateral ones male, peduncle short 1 mm. long in early stages, later 3–4 mm. long at maturity, 0·3–0·5 mm. in diameter, bracts two united into a naviculate structure, 1 mm. long in young stage, later 2 mm. long, apex acute. *Female flowers* oblong-clavate, 2–3 mm. long, 1 mm. diameter, 4 tepals. *Male flowers* in the axil of bract, 0·7 mm. long. *Fruits* single in each inflorescence, clavate or oval, upper part sub-globose, 6–8 mm. long, 4–5 mm. in diameter, base abruptly tapering into stalk, 2–3 mm. long, 0·6 mm. in diameter, remnant of style as a small nipple-shaped outgrowth at the tip, immature fruits in Herb. specimens superficially rugulose, somewhat smooth but never verruculose, nor granulose, but mature fruits superficially very slightly granulose. (Description from the specimens of the Calcutta Herbarium and partly adapted from Danser *loc. cit.*) (Fig. 15.)

The writer has examined the type from Dehra Dun Herbarium. This is a good species.

Only two sheets from Burma were examined by Danser whereas there are a few more Burma specimens of this species from other localities now found out in the Calcutta Herbarium. Hence, they form new records for those areas.

In general appearance and by its stalked fruit, this species shows a superficial resemblance to *Viscum ovalifolium* on one side and *Viscum multinerve* on the other. But it can be readily distinguished from the former by the presence of long and very thin internodes, very prominent fruit stalk and by the absence of warty fruit wall and from the latter by its obtuse, tri-nerved leaves and simple structure of the inflorescence. A Burma specimen of *V. ovalifolium* (*Meebold* 14317) resembles so close to this new species in the shape of the leaves and general appearance that it can be distinguished only by its distinctly warted fruit.

So far, this has been recorded only from Upper Burma that too on either side of Irrawaddy in Minbu and Magwe Districts (Map 3 E). *Specimens examined*

BURMA: Ywamun-Shwetandaw 800 ft., Magwe Dt., *Robertson* 1823 (parasitic on *Acacia leucophlœa*, Berries red, *Type* of the species) (Dehra Dun Herb.); Meiktila, *Collett* 1, in Oct. 1887;

Fig. 15. *Viscum acaciæ* Danser. Shoot with fruits (*Robertson* 1823, *Type* specimen).

Upper Burma, *Collett* 15, in 1887; Upper Burma, *Huk*, in Jan. 1891 (new record); Gwingyin, Minbu Dist., Upper Burma, *Aubert* and *Gage*, on 18–3–1903 (parasitic on *Acacia leuco-phlœa* Willd.) (new record); Sagu Road side, Minbu, *Shaik Mokim* 416, in Oct. 1902 (new record).

(i) **Viscum acaciæ** Danser var. **obovalifolium** Seshagiri Rao *var. nov.*

Varietas hæc nova ad *v. acaciæ* accedit, in eo quod inflorescentia triflora monstrat florem femineum centralem et duos flores masculos laterales; differt vero sequentibus notis: folia sunt obovata, spatium internodale est breve, rotundatum, plus minusve læve in ramis infimis (Fig. 16).

FIG. 16. *Viscum acaciæ* Danser var. *obovalifolium* Seshagiri Rao. A. Shoot (*Huk* 117); B & C. Different shapes of leaves.

This variety is based on the three specimens collected from Shan Hills (*Huk* 117) which are only in the young flowering stage.   The three-flowered inflorescence is typically similar to that of *V. acaciæ*, having a central female flower and lateral male flowers.   But the obovate-lanceo-late leaves and the short, round, more or less smooth internodes in the lower branches of the plants are characteristically different from *V. acaciæ*. By general appearance, it may approach *V. wrayi* and *V. orientale* but can be readily distinguished from the former by the pre-sence of round internodes right upto the apex and from the latter by the three-flowered inflorescence.

Until more collections of *V. acaciæ* are studied when there may be a possibility of finding out the intermediates between the species proper

and this variety, it has been considered to be appropriate to keep this as a distinct variety to draw further attention of other workers on this genus.

The variety has so far been recorded from the Shan Hills, upper Burma (Map 3 F).

Specimens examined

BURMA: Shan Hills, Upper Burma, *Huk* 117, in 1882 (Fl. white, *type* of the variety).

11. **Viscum orientale** Willdenow, *Sp. pl.*, **4** (2): 737, 1805; A. P. de Candolle, *Prodr.*, **4**: 278. 1830 pro parte; Wight and Arnott, *Prodr.*, 379, 1834; Oliver in *Jour. Linn. Soc. Bot.*, **7**: 103, 1864; Brandis, *For. Fl. N.-W. Centr. India*, 393, 1874; pro parte; Kurz, *For. Fl. Burma.* **2**: 324, 1877 pro parte? Hooker f., *Fl. Br. Ind.*, **5**: 224, 1886 pro parte; Engler in *Nat. Pflanzenfam*, **3** (1): 195, 1889 pro parte; Trimen, *Fl. Ceylon*, **3**: 471, 1895 pro parte?; Engler in *Nat. Pflanzenfam.*, 140, 1897 pro parte; Gamble, *Ind. Timbers*, 584, 1902 pro parte; Brandis, *Ind. Trees*, 552, 1906; Cooke, *Fl. Pres. Bombay*, **2** (3): 552, 1906; Talbot, *For. Fl. Bombay*, **2**: 420, 1911 pro parte?; Haines, *Botany Bihar and Orissa*, **5**: 803, 1924; Gamble, *Fl. Madras*, **7**: 1257, 1258, 1925; Fischer in *Rec. Bot. Surv. India*, **11** (1): 161, t. 1, 2 and 4, 1926; Alston in *Trimen Fl. Ceylon*, **6**: 250, 1931; Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **16**: 53, 1938 pro parte, excl. synonym; Danser in *Blumea*, **4**: 299, 1941; *V. verticillatum* Roxburgh, *Fl. Ind.* (ed. 2) **3**: 764, 1832; (ed. 3), 715, 1874; *V. verruculosum* Talbot, *For. Fl. Bombay*, **2**: 419, 1911, pro parte (non Wight and Arnott).

Plants monœcious. *Stems* up to 45 cm. long or even more, terete with swollen nodes, much branched, branches decussate or more than two, dichotomously or umbellately arranged towards the apices; oldest internodes up to 6 cm. long, 6 mm. in diameter, normally smooth, sometimes slightly striped; younger internodes gradually less thick, usually shorter, youngest 1–3 cm. long, up to 1 mm. in diameter, somewhat grooved, flattened, dilated nearly double their normal width at their apices just below the node. *Leaves* opposite, ovate or oblong or somewhat obovate, rarely lanceolate, apex obtuse or acute or rotund, margin entire, thinly coriaceous, sometimes inequilateral, somewhat contracted at base tapering into a narrow very short petiole-like structure, 2–6 cm. long, very rarely upto 7·5 cm., 0·6–3 cm. broad, very rarely upto 3·5 cm., normally with 3-longitudinal nerves, more distinct above. *Inflorescences* usually lateral, at first single in axils, later up to cymes at each node, rarely terminal on tips of weak twigs, peduncle 1–5 mm. long, slightly grooved, bearing on its apex navicular cup formed of 2 bracts connate at base, about 2 mm. long; usually 5 flowers in each cup, the middle 3 female, the lateral male; very rarely another pair of bracts above the lower pair with similar set of flowers. *Female*

flowers oblong, tepals small, triangular. *Male flowers* shorter and more strongly compressed. *Fruits* roundish to oblong-oval, contracted at apex, surface dull by minute granules, smooth, never warty, the largest fruit up to 6 mm. long, 5 mm. in diameter. (Description from the Calcutta Herbarium specimens and partly adapted from Danser, *loc. cit.*) (Fig. 17.)

FIG. 17. *Viscum orientale* Willd. A. Shoot with fruits; B. Fruit enlarged.

Viscum orientale has been confused with many other species by several workers. The identification of Java specimens of *V. ovalifolium* as *V. orientale* by Blume dates back as early as 1823, and later, all the subsequent authors included the Malayan Archipelago specimens of *V. ovalifolium* under *V. orientale*. In Hooker's *Flora of British India*, the description under *V. orientale* is a mixture of the real *V. orientale* and also of *V. heyneanum*, *V. monoicum*, *V. ovalifolium* and the Australian *V. whitei*. *Viscum orientale* described by Bentham in his *Flora Australiensis* is nothing but *V. whitei* and that of his *Flora Hongkongensis* is *V. ovalifolium*.

In the specimens examined below, the leaves are more or less uniform but those in the *Wall. Cat.* 491 E, "*Viscum orientale* ? var. *angustum*" and *Herb. Wight* 1219 are clearly lanceolate and narrow and thus, are quite distinct from the normal ovate or obovate leaves. However, the inflorescence and fruits are typical of *V. orientale*. In a South Indian specimen collected from Rampa Hills (*Narayanaswami* 565), the leaves are unusually big with 7·5 cm. of length and 3·5 cm. of width.

Now, with the understanding of *V. orientale* and its separation from *V. ovalifolium* and other close allies, the area of the distribution of this species appears to be rather restricted mostly in the Peninsular India and Ceylon, extending as far as Bihar and West Bengal as its North-Eastern limit. However, there is so far no record of its occurrence in Burma and Malayan zone where *V. ovalifolium* is commonly distributed (Map 2 B).

Specimens examined

> *Wall. Cat.* no. 491, 491 B, 491 C, 491 E.

INDIA: *Bengal and Bihar :* Singchum, *Haines* 349; Kumarbera, Saranda, Chota-Nagpur, *Gamble* 9106; Base of mount Paresh-nath, *Hooker*; Mutlah, Calcutta, *Clarke* 21652 C; Hazaribagh 2,000 ft.; Chota-Nagpur, *Meebold* 5024; Manbhum, *Campbell*, *Herb. Watt.* 9224.

C. India : Raipore, C.P., *Loemie* in 1910.

Peninsular India : Peninsular India orientalis, *Herb. Wight* 1219; *Herb Wight*, Kew Distr., no. 1249: *Herb. Wight* 46; *Roxburgh* s.n. "*(Viscum verticillatum)*"; Kaliyaguda 1,500 ft., Ganjam Dt., *Gamble* 13837; Gunjugudem, Godavari Dt., *Ramaswamy* 1635; Ethakonda, Rampa country, Godavari Dt., *Narayana swami* 565; Gokavaram and Chodavaram, Godavari Dt., *Narayanaswamy* 6; Pulomamri 500 ft.; Godavari Dt., *Gamble* 15866; Jidikuppa, Krishna Dt., *Barber* 5337; Ramapatam, Nellore Dt., *Gamble* 12380; Thanakonda 1,000 ft., Cuddapah Dt., *Gamble* 21206; Martalli 1,300 ft., Coimbatore Dt., *Fischer* 116; Ramapuram 2,000 ft., Coimbatore Dt., *Fischer* 103; Druttupallam 1,500 ft., Bolam patti Valley, Coimbatore Dt., *Fischer* 1923; Mettupalayam, Coimbatore Dt., *Barber* 8549; Damanul, *Herb. Beckett* no. 1579; Lower Pulneys 3,000 ft., *Rodriguez* 1914; Somanathpur, Mysore State, *Barber* 6857 (*b*); Palghat 500 ft., South Malabar, *Fischer* 1707; Attapadi Valley 1,400 ft., near Gopivan, South Malabar, *Fischer* 1743; Mont. Nilgiri and Kurg, *Herb. H.f. & T.T.*; Gudalur 5,000 ft., Nilgiris, *Meebold* 11484; Bodimetta Ghat 1,000 ft., Madura Dt., *Meebold* 13731; Dedmune, North Kanara Dt., *Talbot* 3573, growing on *Garcinia xanthochymus*; Bangalore. *Santapau* on 6–1–1951, on *Helicteres isora*.

CEYLON: *Thwaites* C.P. 412.

12. **Viscum heyneanum** A. P. de Candolle, *Prodr.*, **4**: 278, 1830;
Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **16**: 51, 1938;
Danser in *Blumea*, **4**: 301, 1941; *V. heyneanum* var. *lio-carpum* Danser in *Blumea*, **4**: 305, 1941; *Viscum verruculo-sum* Wight, Arnott, and *Prodr. Fl. Pen. Ind. Or.*, 379, 1834;
Hooker f., *Fl. Br. Ind.*, **5**: 224, 1886; Engler in *Nat. Pflan-zenfam.*, 140, 1897; Gamble, *Ind. Timb.*, 584, 1902; Brandis,
Ind. Trees, 552, 1906; Talbot in *For. Fl. Bombay*, **2**: 419,
1911 (specimen wrongly quoted); Gamble, *Fl. Madras*,
7: 1257, 1258, 1925; Fischer in *Rec. Bot. Surv. India*, **11**:
180, 1926; Alston in *Trimen Hand. Fl. Ceylon*, **6**: 250, 1931;
Engler and Krause in *Nat. Pflanzenfam.* (ed. 2), **16** *b*: 201,
1935; *V. orbiculatum* Wight, *Ic. Pl.*, **3**: 13, t. 1016, 1845;
Hooker f., *Fl. Br. Ind.*, **5**: 224, 1886; Engler in *Nat. Pflan-zenfam.*, **3** (1): 167, 1889; 140, 1897; Gamble, *Ind. Timb.*, 594,
1902; Brandis, *Ind. Trees*, 552, 1906; Gamble, *Fl. Madras*,
7: 1257, 1258, 1925; Fischer in *Rec. Bot. Surv. India*, **11**:
181, 1926; Engler and Krause in *Nat. Pflanzenfam.* (ed. 2),
16 *b*: 201, 1935; *V. orientale* Thwaites, *Enum. Pl. zey.*,
136, 1859 (non Willd.); Brandis, *For. Fl. N.W. & C. Ind.*,
393, 1874 pro parte; Trimen, *Syst. Cat. Ceylon*, 77, 1885;
Hooker f. *Fl., Br. Ind.*, **5**: 224, 1886; Engler in *Nat. Pflanzen-fam.*, **3** (1): 195, 1889; Trimen, *Hand. Fl. Ceylon*, **3**: 471,
1895; Engler in *Nat. Pflanzenfam.*, 140, 1897 pro parte;
V. capitellatum Lecomte, *Not. Syst.*, **3**: 171, 1915; *Fl. Indo-China*, **5** (3): 209, 1915.

Plants monœcious. *Stems* 40 cm. or longer, much branched, lower
portion with decussate branches or more than two, dichotomously or
umbellately branched towards the apices; lower internodes terete, up to
5 cm. long, up to 5 mm. in diameter, thickened at nodes, upper inter-
nodes gradually less thick, shorter, 1–2 cm. long, grooved, slightly flat-
tened or angular towards apices. *Leaves* opposite, shape very variable,
roundish-ovate to obovate or nearly cuneate-obovate or elliptic to ob-
long lanceolate, apex acute to rotund, margin entire or slightly wavy
or finely crisp, dull or somewhat more shining above, slightly coriaceous,
slightly contracted towards base tapering into a narrow, very short
petiole-like structure, lamina 1·5–5 cm. long, 0·6–2·5 cm. broad, with
3–5 longitudinal nerves, network of venation slightly more distinct
above. *Inflorescences* usually lateral, axillary, up to 6 cymes at each
node, peduncle, very short upto 2 mm. long, slightly grooved, bearing
at its apex naviculate cup formed of 2 bracts connate at base, about
1·5–2 mm. long; usually 3–7 sessile flowers in each cup, outer ones
usually male, others female. *Fruits* oblong, more attenuate towards
both ends in young stage, less attenuate in mature fruits, dull, finely
papillose or typically warty in young stages, less warty or entirely smooth
in older stages often crowned by dry, persistent tepals, up to 5 mm. long,
up to 2 mm. in diameter. (Description from the specimens of the
Calcutta Herbarium and partly adapted from Danser, *loc. cit.*) (Fig. 18).

Fig. 18. *Viscum heyneanum* A.P. de Cand. A. Shoot with fruits (*Bourne* 258); B. Warty fruit (i) and smooth fruit (ii) enlarged.

In general appearance, *V. heyneanum* resembles *V. orientale* and also *V. monoicum*. But a close study reveals that *V. heyneanum* has more strongly and abruptly dilated apices of the stem than those of *V. orientale* and the structure of inflorescence though mostly similar in both, the former has mostly short peduncled or even subsessile inflorescence with normally greater number of flowers whereas in the latter species, number of flowers are comparatively less. However, the young fruits of *V. heyneanum* with their oblong, tapering towards both ends, warty and usually persistent perianth characters, offer the most

distinctive diagnosis. But the number, development and the nature of warts on the fruits are variable and in the ripe fruits, they are less distinct or may even disappear making the fruit appear smooth. Certain ripe fruits on specimens, *Wight* 51 and 47 are nearly oval and smooth resembling those of *V. orientale* and some of them on *Wight* 51, 47, *Fischer* 805 and *Bourne* 258 are oblong, attenuate at both ends and smooth. The young fruits on these specimens are, however, warty. The presence of such numerous smooth fruits on certain specimens has probably led Danser to form a new variety *V. heyneanum* var. *liocarpum*. Though the writer has not seen the type of the variety, the specimen collected by Bourne from Sirumalais, Pulney District (*Bourne* 258 but Danser quotes *Bourne* 1767 from Kew Herbarium) has numerous smooth fruits mixed here and there with young warty fruits. As it has already been noted that warty nature is variable in different ages of the fruit and as the above specimens show the intermediate characters, namely, the combination of smooth and warty characters on their fruits, the formation of a new variety on the basis of entirely smooth fruits may not, however, be justified.

V. heyneanum can be critically distinguished from *V. monoicum* by the presence of usually three-nerved leaves and by the fruit which though smooth when ripe, is oblong and typically attenuate at both ends.

De Candolle, while describing *V. heyneanum* in his *Prodromus*, has not at all mentioned about the warty nature of the fruits and this has probably led Hooker to include *V. heyneanum* under *V. orientale*, thereby using Wight and Arnott's name, *V. verruculosum* for the plants with warty fruits. However, Danser has now clearly pointed out that De Candolle's type specimen preserved in Geneva Herbarium has strongly warted fruits and does not at all come under *V. orientale*.

V. orbiculatum has been accepted as a distinct species by Hooker and Gamble. Though Gamble points out that the smooth fruits and the presence of male flowers in the middle of the trials are the distinguishing characters of *V. orbiculatum* from *V. verruculosum*, it has also been found out that the specimens noted as *V. orbiculatum* by Gamble also show warty fruits with the characteristic shape without any difference in the structure of inflorescence from that of *V. heyneanum*. Hence, *V. verruculosum* and *V. orbiculatum* have been considered as synonyms to *V. heyneanum*.

Strangely enough, *V. heyneanum* which is so closely related to *V. orientale*, has a very restricted distribution in the Deccan peninsula and Ceylon, occurring only in various places south of Nellore. It appears to be very common in the Nilgiri and Travancore hills reaching as far as 7,000 ft. altitude. Danser records the occurrence of this species in Jafna, Pointe de Galles and a few other places in Ceylon. He has also recorded as very doubtful the occurrence of this species in French Indo-China on the basis of Pierre's specimen 3081 preserved in he Paris Herbarium. It appears rather doubtful whether the species of such a restricted distribution can occur at such a distant place as French Indo-China (Map 1 C).

Specimens examined

> *Wall. Cat.* no. 491 A, Herb. Heyne; *Wall. Cat.* no. 6875, on trees about 2,500 ft. above the peak.

INDIA: *Peninsular India:* Horsleykonda 3,500 ft., Chittoor Dt., *Fischer* 4319; Shombaganur, S. India, *Auglade* 1871; Panachi 3,000 ft., Anamalai Hills, *Fischer* 3468; Dimbam 3,700 ft., Coimbatore Dt., *Fischer* 805; Black bridge 6,000 ft., Nilgiri Dt., *Gamble* 12114, on *Loranthus* on *Eugenia;* Bikkatti 5,000 ft., Nilgiri Dt., *Gamble* 20669; High wavy mountain 4,000–5,500 ft., S. India, *Blatter* and *Hallberg* 44; Travancore, *Bourdillon* 298, on *Helicteres isora*; Maluguttur 100 ft., Travancore, *Bourdillon* 650; Mundemurai, Travancore State, *Calder and Ramaswamy* 238; Thorai, Travancore, *Rama Rao* 1533; *loc.* ? Ex *Herb. Wight* 45, 47, 51; Sirumalais, Pulney District, *Bourne* 258.

13. **Viscum monoicum** Roxburgh ex A. P. de Candolle, *Prodr.*, **4**: 278, 1830; Roxburgh, *Fl. Ind.* (ed. 2), **3**: 763, 1832; Wight and Arnott, *Prodr. Fl. Pen. Ind. Or.*, 379, 1834; Roxburgh, *Fl. Ind.* (ed. 3), 715, 1874; Brandis, *For. Fl. N.-W. & Centr. Ind.*, 393, 1874; Kurz, *For. Fl. Burma*, **2**: 324, 1877; Hooker f., *Fl. Br. Ind.*, **5**: 224, 1886 (*cum* var. *edgeworthii*); Clarke in *Jour. Soc. Bot.*, **25**: 64, 1889; Engler in *Nat. Pflanzenfam.*, **3** (1): 194, 1889; Trimen, *Handb. Fl. Ceylon*, **3**: 471, 1895; Engler in *Nat. Pflanzenfam.*, 140, 1897; Gamble, *Ind. Timb.*, 584, 1902; Burkill in *Rec. Bot. Surv. India*, **4** (4): 77, 129, 1904; Cooke, *Fl. Bombay*, **2**: 552, 1906 pro parte ?; Brandis, *Ind. Trees*, 552, 716, 1906; Gamble in *Jour. As. Soc. Beng.*, **75** (2): 386, 1914; Duthie, *Fl. Upp. Ganget. Plain*, **3** (1): 68, 1915; Lecomte, *Fl. Indo-Chine*, **5** (3), 208, 1915; Haines, *Bot. Bihar & Orissa*, **5**: 803, 1924; Gamble, *Fl. Madras*, **7**: 1257, 1258, 1925; Fischer in *Rec. Bot. Surv. India*, **11** (1): 161, 1926; Cowan in *Rec. Bot. Surv. Ind.*, **11** (2): 221, 1928; Kanjilal, *For. Fl. Pilibhit*, etc., 319, 1933; Engler and Krause in *Nat. Pflanzenfam.* (ed. 2), **16** *b*: 201, 1925; Kanjilal *et al.*, *Fl. Assam*, **4**: 118, 1940; Danser in *Blumea*, **4**: 305, 1941 (excl. syn. *V. verruculosum* Talb.); Santapau in *Rec. Bot. Surv. Ind.*, **16** (1): 268, 1953 (excl. syn.); *V. falcatum* A. P. de Cand., *Prodr.*, **4**: 278, 1830; *V. confertum* Roxb., *Fl. Ind.* (ed. 2), **3**: 764, 1832; (ed. 3) 715, 1874; *V. benghalensis* Roxb. ex Wt. & Ar., *Prodr.*, 379, 1834 in *synonymis*; *V. edgeworthii* Brandis, *Ind. Trees*, 552, 1906; *V. orientale* Talbot, *For. Fl. Bombay*, **2**: 421, 1911 (non *Willd.*), pro parte; Danser in *Bull. Jard. Bot. Buitenzorg* (ser. 3), **16**: 53, t. 1, ic. 3*d–g*, 1938 (non *Willd.*).

Plants monœcious. *Stems* yellowish, 40 cm. or longer, much branched, decussate in lower parts, dichotomous towards apices, a pair of scales (prophylls) at the base of every branching, usually indistinct; internodes terete, thickened at nodes, oldest ones 2–7 cm. long, up to 10 mm. in diameter, smooth or longitudinally wrinkled, youngest ones

1–3·5 cm. long, 0·5–1·5 mm. in diameter. *Leaves* opposite, elliptic to lanceolate, usually somewhat falcate, oblique, apex acute or somewhat acuminate, margin entire or somewhat wavy, surface dull or slightly shining, thinly coriaceous, attenuate at base tapering into a very short petiole-like structure, lamina 2·5–10 cm. long, 0·6–3 cm. broad, very rarely slightly longer and broader, with usually 5 very rarely 3 or 7 longitudinal nerves, network of venation slightly distinct above. *Inflorescences* usually lateral, at first single in axils, later up to 6 cymes at each node, peduncle absent or very short up to 2 mm. long, bearing at its base one or more pairs of scales, at its apex navicular cup formed of 2 connate bracts, cup up to 4 mm. long; usually 5, more rarely 3 or 7 sessile flowers in each cup, outer ones male, others female. *Female flowers* clavate or obovate, about 1·5 mm. long with 4 tepals. *Male flowers* oblong compressed, 1 mm. long. *Fruits* usually oblong, truncate at apex, attenuate to rounded at base, green, shining, distinctly smooth, sometimes wrinkled due to drying, up to 4–6 mm. long, 2–3 mm. in diameter. (Description from the specimens of the Calcutta and other herbaria and partly adapted from Danser, *loc. cit.*) (Fig. 19.)

Viscum monoicum has been confused with *V. orientale* by several workers. Talbot (1911) notes "*V. monoicum* Roxb. scarcely differs from *V. orientale* and should I think be united with it." But *V. monoicum* is a well-defined species with usually 5 or more rarely 3 or 7 longitudinally nerved leaves with acute tips and with characteristic oblong, almost truncate, fruits with entirely smooth and shining surface. This should not be confused with *V. orientale* having usually 3-nerved leaves with mostly obtuse tips and fruits which are roundish when mature, somewhat attenuate towards both ends and dull by fine granulation. Further, *V. orientale* has a restricted distribution not spreading beyond West Bengal which forms its North-Eastern limit. The other close allies of *V. monoicum* are *V. heyneanum* and *V. multinerve* where the leaves in the former are usually 3-nerved, more rarely 5-nerved (besides the characteristic verruculose fruit) and in the latter, a Chinese species, are multinerved.

Specimens collected particularly from Sundribans (*Prain, Heinig*) contain unusually narrow falcate leaves resembling phyllodes of *Acacia* and thus giving an appearance of a variety. But the presence of very narrow and the usual type of leaves on the same specimens from Nilgiris and Sitapahar (*Lister*) indicates that it is just a minor variation not worth to be a varietal character. The specimen from Shan States (*MacGregor* 573) with characteristic oblong fruits shows leaves with more than 5 nerves and appears as *Viscum multinerve*.

This species enjoys a very wide distribution starting from the Peninsular India and Ceylon and reaches its Northern limit up to 4,000 ft. alt. in the East Himalayas and its eastern limit as far as French Indo-China and Siam passing through Burma (Map 4 A).

Specimens examined

Wall. *Cat.* no. 492, Mt. Sillet, Montes Pundua; *Wall. Cat.* no. 492, Sillet et Mont. Pundua, *Wallich* s.n., in 1829 (Originals of

FIG. 19. *Viscum monoicum* Roxb. ex. A.P. de Cand. A. Shoot with fruits; B (i & ii). Different shapes of leaves; C. Fruit enlarged.

V. falcatum de Candolle); *Wall. Cat.* no. 493, Tavoy, 28–5–1827 (*V. obliquum* Wall.)

INDIA: *Bengal, Bihar and Chota-Nagpur :* Tipperah Hill 500–800 ft.; Agartala, *Deb Barman* 511; Tipperan Hill 1,000 ft., Agartala, *Deb Barman* 271; old Agartala 500–800 ft., *Deb Barman* 570, 31–12–1914; Dakobie, Sutakhal, Sundribans, *Prain* s.n.; Sundriban lot No. 226, Sundri forest, Baushanta Khod, *Heinig* s.n., 7–2–1895, on *Excoecaria agallocha* Linn.; Sundribans, *Heinig*, Nov. 1894; Sundribans, lower Bengal, Herb. Sulp.

Kurz, coll. *Kurz*; Mymensingh, *Clarke* 17290 A, 12–7–1872; Tipperah, W. Bengal, *Biswas* 5021, 30–3–1941; Bhirbhoom Hill, coll. ?; Monghir, Bihar, *Kurz*, parasitic on trees; Rajmahal Hills, near Sahebganj, *Kurz*; Madhoban 1,000 ft., Hazaribagh, *Clarke* 34631 A, 9–4–1884; Hazaribagh, *Prain* s.n., 24–11–1891; Amjeria Tori 2,000 ft., Lohaodugga, *Gamble* 8711, on *Adina cordifolia*; Jona, Chota-Nagpur, Nov. 1891, coll. ?; Luneta, below 1,500 ft., Hazaribagh, *Wood* s.n., 18–2–1878.

Assam: Mont. Khasia 3,000 ft., *Hooker and Thomson* s.n.; Sibsagar, coll. ?, on *Butea frondosa;* Dawdobia nodu, Jabocka, near Naga Hills, *Prain's coll.* 742; Roopacherra, Cachar, Assam, *Gage*, 10–8–1903; *Pongtung, K. & J. Hills, *Sharma* 12130, on 29–8–1935; Barpani, K. & J. Hills, *Kanjilal* 6115, on 25–10–1915, on *Dalbergia tamarindifolia*; Dawki forest, K. & J. Hills, *De* 18599, on *Bauhinia purpurea* and others; Longai Reserve, Sylhet Dt., *De* 20214, on *Xanthoxylum budranga* and others; Bilaipur, Cachar Dt., *De* 20215, on *Grewia multiflora*; Ramprasadpur, Dholai, Cachar Dt., *De* 20789, on *Anthocephalus cadamba*; Bokajan, Sibsagar Dt., *De* 16632, on *Punica granatum*; Nowgong, Upper Assam, *Purkayastha* 8075; Khaling Duar Reserve, Darrang Dt., *Kanjilal* 5020, on *Randia dumetorum*. (* Specimens starting from this asterisk are from the Shillong Herbarium.)

E. Himalaya : Sikkim 2–4,000 ft., *Hooker* s.n.

Upper Gangetic Plain : Nepal Frontier, *Inayat* 23819, 27–2–1900.

Peninsular India and Ceylon : Rumpa Hills 2,000 ft., Godavari Dt., *Gamble* 16012; Mont. Nilgiri and Kurg, *Thomson* s.n.; Nilgiris, *Wight*, in 1847; Bombay, *Herb. Dalzell*; Samphand 1,600 ft., North Kanara, 200″ rainfall, *Herb. Sedgwick and Bell* 6883; North Kanara, *Talbot* 780; Udumbansholai 5,000 ft., Travancore, *Meebold* 13034; *Slopes under Elphinstone point, Khandala, *Santapau* 3994, 3995, 3997 to 4005 (on *Mallotus philippinensis*), 6016, 6018, 6019, 6020, 6022, 6023, 6024, 8798, 8799, 8800; Banks of Paudri River, Londa, *Santapau* 10872, on *Vitex leucoxylon*; Patanmal plateau, Khandala, *Santapau* 8951 to 8958; Roadsides under St. Xavier's Khandala, *Santapau*, 4113, 4114, 4115; Fitzgerald Ghat, Mahabaleswar, *Santapau* 12543 (on *Mallotus philippensis*), 12545, 12549.

Burma : Pagaye, Tenasserim, *Meebold* 15053; Tavoy, Tenasserim, *Meebold* 14964; Makhaye Hill, Shan State, Upper Burma, *King's coll.*; Sitapahar, Burma, *Lister*, in 1876; South Shan States, *MacGregor* 573; Amherest, *Falconer*, 4–4–1849.

14. **Viscum trilobatum** Talbot, *For. Fl. Bombay*, **2**: 419, t. 479, 1911; Danser in *Blumea*, **4**: 308, t. 3 A & B, 1941; *Viscum capitellatum* Hooker f., *Fl. Br. Ind.*, **5**: 225, 1886 pro parte (non Smith); Cooke, *Fl. Bombay*, **2**: 552, 1906 pro parte; Gamble, *Fl. Madras*, **7**: 1257, 1258, 1925 pro parte.

Plants monœcious. *Stems* short, rigid, up to 25 cm. long or more, branching decussate in lower portion, dichotomous towards apices by development of terminal inflorescences; lower internodes terete, thickened at nodes, up to 6 cm. long, 5 mm. in diameter, middle ones sometimes slightly longer, gradually less thick, slightly angular or flattened towards the apices, upper ones 1·5–3·5 cm. long, 1·5–3·5 mm. in diameter. *Leaves* opposite, obovate to sub-orbicular or sometimes more cuneate and subtruncate, apex rotund to truncate or slightly retuse or rarely with a small acute tip with two depressions on either side of tip (so-called trilobate), margin entire, surface dull or slightly shining, coriaceous, abruptly or gradually contracted into narrow base sometimes ending in short petiole up to 3 mm. long, lamina 1·5–4·5 cm. long, rarely up to 5·5 cm., 1–4 cm. broad, with 3–5 longitudinal nerves, sometimes completely indistinct appearing as nerveless, network of venation indistinct. *Inflorescences* usually lateral in lower parts, single or up to 3 cymes in axils, terminal in apical parts, usually 3, peduncles absent or very short up to 2 mm. long, rarely slightly longer in terminal cymes, bearing at its tip naviculate cup formed of 2 connate bracts, cup up to 4 mm. long; usually 3 sessile flowers in each cup, lateral female, middle male, very rarely all female; rarely second internode of peduncle in place of middle flower bearing a bracteal cup with one male and two lateral female flowers. *Female flowers* oblong, with 4 tepals. *Male flowers* obovate, about 2 mm. long, 1 mm. broad, with 4 tepals. *Fruits* nearly round or somewhat ovate, slightly constricted just below the small disc-like tepal-bearing rim, smooth or wrinkled due to drying, up to 5 mm. long, 4·5 mm. in diameter. (Description from specimens of the Calcutta and Dehra Dun Herbaria and partly adapted from Danser, *loc. cit.*) (Fig. 20).

V. trilobatum has been included in *V. capitellatum* by all the authors except Talbot and Danser even though they knew the plant quite well with its broader leaves. No doubt, both the species are closely related but, by careful study, it can be observed that the leaves of *V. trilobatum* are distinctly bigger, measuring 1·5–4·5 cm. or rarely up to 5·5 cm. in length whereas in *V. capitellatum*, the leaves, if they do not fall off, are constantly small with their length not beyond 2·5 cm. Further, in *V. trilobatum*, the peduncle is usually absent and even if present, is only up to 2 mm. long whereas in *V. capitellatum*, a prominent peduncle of 3–15 mm. length is always present. After the scrutiny of the following specimens, it is clear that much importance should not be attached to the "trilobate" character of the leaf from which the specific name has been derived. In almost all the specimens examined, there are more leaves which are distinctly obovate with rotund tips, mixed up with sub-orbicular or cuneate and sub-truncate leaves rather than slightly trilobate leaves, indicating the former as the normal leaf shape. So, Talbot's choice of the specific name may not be quite characteristic but the species is clearly a distinct one.

Talbot (1911) quotes the typical specimens of his own new species collected from Siddapore, N. Kanara, under *Viscum verruculosum* Wt. & Arn., saying that his specimens were named like that in the Calcutta

FIG. 20. *Viscum trilobatum* Talbot. A. Shoot with fruits (*Talbot*, 1–4–1889); B (i, ii & iii). Different shapes of leaves.

Herbarium. However, it is rather strange how he mistook them for *V. verruculosum.*

Talbot's specimen from Ioida, North Kanara, which was labelled as *V. capitellatum*, has been considered as the type of *V. trilobatum* by Danser because it resembles the drawing in Talbot's Forest Flora (*loc. cit.*) where it is noted that the species is available in "N. Kanara Dt. in monsoon and rain forests growing on different trees" without quoting any specific collections.

Though the species appears to be common in North Kanara it has also been collected from different parts of South India like Nilgiris and Malabar (Map 4 C).

Specimens examined

INDIA: *Peninsular India :* Ioida, North Kanara, *Talbot*, 1–4–1889 (considered to be *Type*) (Dehra Dun Herb.); Siddapore,

N. Kanara Dt., *Talbot* 3739, on *Loranthus trigonus* Wt.; Unmode, N. Kanara, *Talbot* 1619, on *Loranthus trigonus*; Chedleth 3,000 ft., Malabar, *Fischer* 329, on *Loranthus longiflorus* (Dehra Dun Herb.); Jirganhalli 3,000 ft., Coimbatore Dt., *Fischer* 1020; Sigui 3,000 ft., Nilgiris, *Gamble* 15693.

15. **Viscum capitellatum** Smith, in Rees, *Cyclopedia*, **37**: *Viscum* no. 18, 1817; A. P. de Candolle, *Prodr.*, **4**: 279, 1830; Wight and Arnott, *Prodr. Fl. Pen. Ind. Or.*, 380, 1834; Thwaites, *Enum. Pl. Zeylan*, 136, 1859; Trimen, *Syst. Catal. Ceylon*, 77, 1885; Hooker f., *Fl. Br. Ind.*, **5**: 225, 1886 pro parte; Engler in *Nat. Pflanzenfam.*, **3** (1): 195, 1889; Trimen, *Handb. Fl. Ceylon*, **3**: 471, 1895; Engler in *Nat. Pflanzenfam.*, 140, 1897; Gamble, *Ind. Timbers*, 584, 1902; Brandis, *Ind. Trees*, 552, 1906; Cooke, *Fl. Bombay*, **2**: 552, 1906 pro parte; Talbot, *For. Fl. Bombay*, **2**: 421, t. 480, 1911; Gamble, *Fl. Madras*, **7**: 1257, 1258, 1925 pro parte; Fischer in *Rec. Bot. Surv. India*, **11** (1): 171, 1926; Engler and Krause in *Nat. Pflanzenfam.* (ed. 2), **16** *b*: 201, 1935; Danser in *Blumea*, **4**: 309, t. 2, 1941.

Plants monœcious. *Stems* rigid, up to 15 cm. long, rarely longer, usually shorter, much branched, decussate, divaricate in lower parts, more or less umbellately arranged in upper parts; internodes terete, thickened at nodes, up to 6 cm. long, up to 5 m n. in diameter, smooth or wrinkled, younger ones at apices less thick, shorter, dilated and flattened at tips, 1–2 cm. long, 1–3 n m. in diameter, usually wrinkled, sometimes grooved. *Leaves* normal, sometimes reduced to scales (particularly at bases of bra ches in lower and apical parts, indistinct or absent), sometimes falling off completely (presenting the plant as leafless), opposite, roundish-obovate, rarely somewhat cuneate, apex rotund, margin entire, usually curled upward, surface dull, somewhat coriaceous, abruptly contracted into narrow short base, sessile, lamina 1·5–2·5 cm. long, 5–10 mm. broad, often smaller, with usually 3 longitudinal nerves, often indistinct. *Inflorescences* usually lateral, up to 6 cymes in axils, very rarely terminal, peduncle very prominent 3–15 mm. long, bearing at its tip naviculate cup formed of two bracts connate at base, cup up to 4 mm. long; usually at first one, later up to 5 flowers in each cup, lateral female, central male; rarely second internode of peduncle in place of middle flower bearing a bracteal cup witn probably 5 flowers, the central being male, others female. *Female flowers* somewhat oblong, with 4 tepals. *Male flowers* obovate, about 2 mm. long, 1 mm. broad, with 4 tepals. *Fruits* roundish-ellipsoid or somewhat ovate, distinctly constricted just below the tepal-bearing rim, smooth shining, sometimes wrinkled by drying, up to 3·5 mm. long, 2·5 mm. in diameter. (Description from specimens of the Calcutta Herbarium and partly adapted from Danser, *loc. cit.*) (Fig. 21.)

This species has been correctly understood by most of the workers. From the material examined, it is evident that the young plants have normal leaves which are not more than 2·5 cm. long on most of the nodes but the older plants look almost leafless with their normal leaves
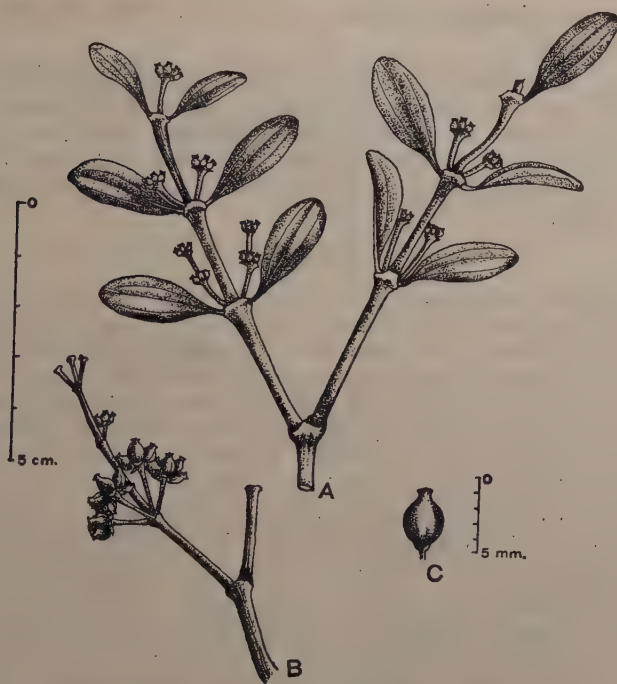
Fig. 21. *Viscum capitellatum* Smith. A. Shoot with young fruits (*Fischer* 24); B. Small twig with mature fruits (*Fischer* 4000); C. Fruit enlarged.

fallen off. This character might be responsible for Wight and Arnott's (1834) varieties *a* and *b* which, however, cannot stand. Sometimes the leaves are almost scale-like towards the base and apex of the plant. Apart from these minor variations, this is a true species and can be easily distinguished from its allies, *V. trilobatum* by their normal leaves, sessile, roundish, obovate, typically obtuse at the apex, thick, dull, usually not more than 2·5 cm. long and inflorescences with prominent peduncles, 3–15 mm. long.

The sheet with *Wall. Cat.* no. 6879, named *Viscum grossum* Wight, has been referred by Hooker f. (1886) and Danser (1941) under doubtful species as the specimen consists of nothing but small bits of branches resembling those of *V. album*. But as *V. album* does not occur in the Deccan Peninsula, Danser (1941) notes under '*Visca dubia*' that the remarks on the sheet by Gamble "Perhaps *V. capitellatum*" may be right.

This species appears to have a restricted distribution in the Deccan Peninsula, extending southwards as far as Ceylon (Map 3 B).

Specimens examined

  Wall. Cat. no. 6878, Herb. *Wight* s.n. (Sheeally on man, etc., *Viscum mangifera* Wall.); *Wall. Cat.* no. 6879, Herb. *Wight*

s.n. (Dindigul, Madras Prov., Dec. 1826, *Viscum grossum* Wight).

INDIA: *Peninsular India:* Near Ovatithu 3,500 ft., Coimbatore Dt., *Fischer* 24; Komattiyeri 2,350 ft., Javadi Hills, *Fischer* 4,000 ft., on *Albizzia odoratissima* and *Loranthus longiflorus*; Maudurei 1,500 ft., N. Kanara, rainfall 150″, *Bell* 6049, Herb. Sedgwick & Bell. (Collections from Ceylon are not available in Calcutta Herb.)

SUMMARY

The present revision is an extension of Danser's studies on the British Indian species of *Viscum*. The genus is mainly distributed in the tropics. Africa claims the largest number of species as many as 50, Madagascar about 40 species and the Indo-Malayan region only 15 species. On the basis of the available data, it appears that the line of distribution might have proceeded from Africa to India through Madagascar and gradually extended further East as far as Japan on one side and tropical Australia on the other.

This revision has considerably augmented the number of species and varieties known for India and Burma and further enlarged the areas of distribution of many species. *V. loranthi* Elmer which exhibits a peculiar discontinuous distribution occurring in China, Luzon, Sumatra and the Western Himalayas, has been newly recorded from the Manipur Hills, Assam. *V. ovalifolium* A. P. de Cand., a purely Malayan species reaching as far as Burma, has been now found out to occur in Assam as a new record for India. *V. articulatum* Burm. var. *liquidambaricolum* (Hayata) Seshagiri Rao, *nov. comb.*, *V. articulatum* Burm. var. *theolocarpum* (Danser) Seshagiri Rao, *nov. comb.* and *V. acaciæ* Danser var. *obovalifolium* Seshagiri Rao, *nov. var.* are the new varieties and combinations.

A detailed illustrated account of all the species and varieties of India, Burma and Malayan Archipelago with the nomenclatural changes and descriptions is given in the paper.

STUDIES IN POLYPODIACEÆ

IV. *Drymoglossum* Presl

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Drymoglossum Presl is one of the few genera of ferns which suffer yet from nomenclatural confusions. The genus is based on the Linnaean *Pteris piloselloides* L. (Linnaeus, 1753). Desvaux (1827) included it in his genus *Pteropsis* Desv. along with nine other species (which incidentally, belong to four different genera according to modern pteriodologists). Presl (1836) treated it as belonging to a monotypic genus *Drymoglossum*, distinct from the genus *Pteropsis* Desv. Christensen (1906) adopted the genus *Drymoglossum* typified by *Achrostichium heterophyllum* L. (cogeneric to *Pteris piloselloides* L.), but considered *Pteropsis* Desv. "*pro parte max. certe nom opt*". Copeland (1947) replaced *Drymoglossum* by *Pteropsis*. Holttum (1949) has pointed out that Desvaux's description of the genus *Pteropsis* agrees most nearly with his *Pteropsis scolopendria* (Bory) Desv. and since this species is now included in *Vittaria* Sm. the genus *Pteropsis* would become a synonym of *Vittaria*. According to him *Pteris piloselloides* L. should be *Drymoglossum piloselloides* (L.) Presl. Recently Pichi-Sermolli (1953) has marshalled detailed evidence to conserve *Drymoglossum* Presl as the generic name instead of *Pteropsis* Desv. to include *Achrostichium heterophyllum* L. *Drymoglossum* Presl as here construed is a small genus of epiphytic ferns, of which *D. piloselloides* (L.) Presl is the type and sole species. Five other tentative species are recognised by some pteridologists while others tend to consider them as morphological varieties of the type species. An elucidation of the phylogeny of the genus, based on salient morphological features of the gametophyte and the sporophyte, is attempted here. Three tentative 'varieties', differing mainly in leaf form, size of the plant and density of foliar dermal appendages have been used, but as detailed studies reveal no clear differences between them, they are treated as a single species. Material for this study was collected from the plains of North-Eastern and South-Western India and the methods followed are the same as described earlier (Kachroo & Nayar, 1953). The acetolysis method (Erdtman, 1954) is used to study spore morphology.

Drymoglossum grows adpressed to the trunks and branches of trees usually clothing the substratum and forming in some cases hanging tassels. Though generally inhabiting shaded regions, it is not uncommon in exposed areas. The rhizome is slender (ca. 1·20 mm. in diameter), creeping, branched and attached to the substratum by means of numerous black adventitious roots. Leaves are sparse and branches bear no relation to them. Peltate, shield-like paleæ clothe the growing

TEXT-FIGS. 1–5. Figs. 1 *a*–1 *e*. Paleæ from rhizome. Fig. 2. T.s. stem (portion only) showing one vascular strand; *e.*, epidermis; *en.*, endodermis; *ic.*, inner cortex; *oc.*, outer cortex; *s.*, sclerenchyma sheath. Figs. 3, 4, 5. Vascular skeleton of portion of rhizome showing origin of leaf and branch-traces; *br.*, branch trace; *D.*, dorsal surface of rhizome; *lt.*, leaf trace; *r.*, root trace; *V.*, ventral surface of rhizome.

apices but become sparse in older regions, due to increase in length of the rhizome. They vary from ovate-lanceolate to ovoid, having either a tapering or blunt apex (Figs. 1 *a*, 1 *b*). The margin is dentate, the

dentations in some cases growing out as hairs. A large number of paleæ possesses a distinctly ciliate margin (Fig. 1 c) and all intermediate stages leading on to a smooth margin (Fig. 1 d) occur even on the same branch. The paleæ vary much in size and some of the smaller ones lack a tapering apex (Fig. 1 d) the smallest simulating peltate hairs (Fig. 1 e). No glandular cells occur either at the apex or margin. The stalk of the palea is short and slender (usually 4 cells thick and 2–3 cells long), attached towards the centre of the broad basal region and pierce the epidermis of the rhizome to rest on an expanded foot bordered by regularly arranged cortical cells. Ontogeny of the paleæ is similar to that in *Pyrrosia* (Nayar, 1957).

The epidermis of the rhizome is slightly thick-walled and regular. Cortex is divided into an outer and an inner region by a sclerenchyma sheath 3–5 cells thick (Fig. 2). The cells of the outer cortex (2–3 rows) have walls as thick as those of the epidermal cells; they are hyaline and have small intercellular spaces. The inner cortex (3–5 cells thick) and the pith with which it is contiguous are composed of thin-walled parenchyma cells with rounded corners, conspicuous intercellular spaces and dense deposits of starch. Cells of the sclerenchyma sheath are smaller (in t.s.) than the cortical cells, with highly thickened deep brown walls having lamellations and pit connections. The vascular cylinder is a ' false dictyostele ' (*see* Nayar and Kachroo, 1953) as in *Pyrrosia*. Each rhizome generally has 3–4 vascular bundles which branch and anastomose irregularly. Generally the median vascular bundle is conspicuously bigger than the others. In extremely slender rhizomes leaf traces originate from either side of the dorsal median vascular bundle in alternate succession, while in the thicker rhizomes the dorsal median bundle is free, the traces originating alternately from the lateral bundles on either side of it (Fig. 3). Intermediate stages where a lateral branch of the median bundle immediately after its origin gives off a leaf trace are common (Fig. 4). Leaves of the smaller varieties have but a single leaf trace splitting into two just before entering the leaf base (Figs. 3, 4—*lt.*). Traces to bigger leaves split into two earlier while passing through the cortex and some of the biggest leaves have two separate traces originating successively from the same vascular bundle of the rhizome (Fig. 5). Vascular connections to the branches are established by two vascular strands of the rhizome [either, branches of two separate rhizome bundles (Fig. 5—*br.*) or one of the smaller rhizome bundles and a branch of the one next to it (Fig. 3—*br.*)] curving outwards, fusing in the cortex and entering the branch base. In the branch the single strand becomes medullated and later splits into distinct bundles arranged in a cylinder as in the main rhizome. Root traces originate irregularly as superficial branches of the vascular bundles. Leaf-, branch- and root-traces on passing through the cortical sclerenchyma sheath of the rhizome, acquire a closed sheath of their own. Structurally the root is similar to that of *Pyrrosia* (Nayar, 1957).

Leaves vary in size and shape in different parts of the same plant. In all cases they are alternate, sparsely arranged on the rhizome, simple, short stipitate, articulate to the rhizome and with entire margin, rounded

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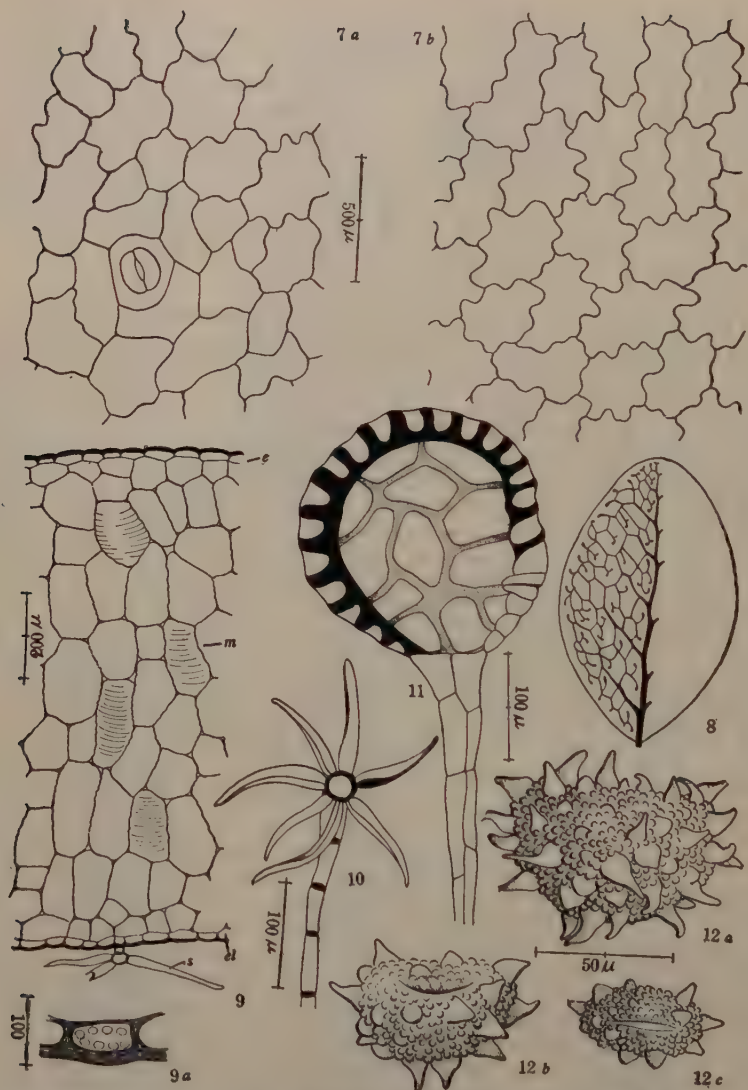
TEXT-FIGS. 7–12. Fig. 7 a. Lower foliar epidermis. Fig. 7 b. Upper foliar epidermis. Fig. 8. Leaf showing venation. Fig. 9. T.s. of portion of leaf lamina; e., upper epidermis; el., lower epidermis; m., mesophyll; s., trichome. Fig. 9 a. T.s. one cell of lower epidermis. Fig. 10. Paraphysis. Fig. 11. Lateral view of sporangium. Fig. 12 a. Lateral view of a giant spore. Fig. 12 b. Proximo-lateral view of an ordinary spore. Fig. 12 c. Proximal view of a midget spore.

tips and fleshy texture. Usually they are ovate-spatulate but in some varieties oblong or rarely round. Phyllopodia are well developed, up to 2·00 mm. long, as thick as the petiole and paleate. Stellate hairs like

those of *Pyrrosia adnascens* cover the petiole and occur sparsely on the mature lamina. Hairs are more profuse on young leaves and in some varieties persist·for a longer time on the lamina. Leaves of the latter type are generally less fleshy and are broader. Petiole is short (ca. 1·00–2·00 mm.), terete, brownish and composed of moderately thick-walled cells (with prominent intercellular spaces) surrounding the central vascular strands. A cortical sheath of sclerenchyma occurs in the phyllopodium. As in *Pyrrosia*, a saucer-shaped disc of small paren-chyma cells, with the cells near the periphery elongated radially, consti-tutes the articulation (Plate VI, Fig. 6). Venation of the lamina is reti-culate (Fig. 8), with a midrib (discernable superficially on the basal half of the lamina only) and alternating lateral veins. The latter as well as the reticulations are hidden. Successive lateral veins are connected by regular cross-veins forming a row of æreolæ, the bigger ones of which are divided by the tertiary veins parallel to the main laterals. Towards the margin finer reticulations also may occur. Free ending veinlets, one per each mesh of the reticulation and forking once or twice, arise from the secondary veins towards the midrib or from the tertiary veins where the latter occur. Free ending veinlets project from the outer face of the marginal æreolæ and end blindly. The two vascular bundles of the petiole fuse into one in the midrib. Epidermal cells of the lamina have thick lamellated walls (Fig. 9 *a*) and an irregularly wavy outline (Figs. 7 *a*, 7 *b*). Stomata are abundant on the lower epidermis and are similar to those in *Pyrrosia*, being completely surrounded by a single epidermal cell with a more or less regular outline. A few stomata occur on the upper epidermis as well and in this case they are sunken. Each stoma in early stages is attached to one of the anterior corners of the epidermal cell which later surrounds it. As the epidermal cell expands, the middle lamella connecting the stoma with the mother cell disappears and the stoma becomes gradually pushed towards the centre of the cell. The mesophyll is undifferentiated and is composed of paren-chyma cells the middle layers of which are radially elongated (Fig. 9). Radial walls of these cells have bellows-like foldings which become more prominent during wilting. All cells including the lower epidermal cells are chlorophyllous.

Fertile leaves are distinct from sterile ones in being 3–4 times longer and extremely narrow (2·00–10·00 cm. × 0·25–0·75 cm.). They are sti-pitate and articulate, with a blunt apex and parallel sides. Sporangia are crowded on the dorsal surface covering the whole surface except the extreme margin and midrib. Rarely, the fertile region is restricted towards the margins on the under-surface, the sori being broad and linear. Paraphyses (Fig. 10) of the *Pyrrosia*-type cover the sporangia during the early stages. The stalk of the sporangium is 4 cells long and 3 cells thick at the anterior end. The annulus is continuous with the stalk as in *Pyrrosia*, consists of 14–19 cells and borders on the sto-mium which is 4–celled with well-developed lip cells (Fig. 11). The cells of the sporangial wall are thick-walled, light brown, with more or less regular outline and equi-dimensional. Spores are bilateral, monolete, with the læsura short, simple, tapering to either end, generally 42 × 70 μ on an average, plano-concave in profile and with the cross-section
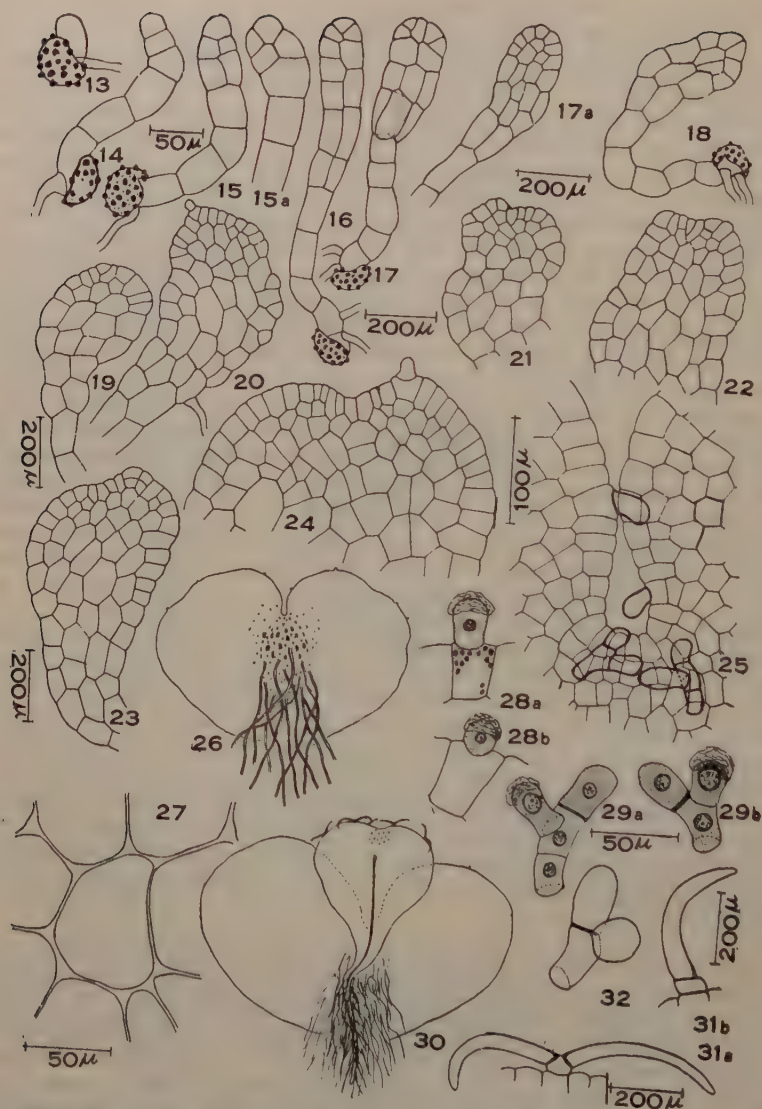
Text-Figs. 13–32. Figs. 13–24. Stages in the development of prothallus (for details see text). Fig. 25. Apex of mature prothallus. Fig. 26. Mature cordate prothallus (under-surface). Fig. 27. Wing cells of mature prothallus showing collenchymatous thickenings. Figs. 28 a, 28 b. Marginal unicellular hairs of mature prothallus. Figs. 29 a, 29 b. Superficial prothallial hairs from under-surface of midrib. Fig. 30. Mature gametophyte with attached sporophyte (lower surface). Figs. 31a, 31 b. Marginal star hairs on first juvenile leaf. Fig. 32. Branched superficial hair of first juvenile leaf.

rounded proximally (Figs. 12 *a*, 12 *b*, 12 *c*). The exine is echino-verrucate with the echinations scattered, sometimes 8 μ in length and often curved. The surface between the echinations is verrucate with small hemispheric projections and intermediate structures leading on to echinations. The spore size varies from $25 \times 50 \mu$ to $55 \times 95 \mu$. The P : E ratio averages 4 : 7 (Terminology after Harris, 1955). Under laboratory conditions the spores germinate rather slowly taking, in some cases, 3–4 months for the emergence of the germ papilla. Usually the rhizoid emerges first and is pale violet brown in colour as in *Pyrrosia* (Nayar, 1957) and *Platycerium* (Stokey and Atkinson, 1954). The germ papilla is lateral in origin (Fig. 13) and forms a 4–5-celled, densely chloro-phyllous germ tube (Fig. 14). Branching of the germ tube and forma-tion of more than one tube per spore were noted very occasionally in cul-tures. Under insufficient light conditions the germ tubes elongate in-definitely and may branch. Usually when the germ tube is 4–6 cells long, the anterior cells including the dome-shaped apical cell divide longi-tudinally initiating flattening (Figs. 15, 15 *a*, 16). Soon a spatulate pro-thallus devoid of a definite meristem is formed (Figs. 17, 17*a*, 18). An apical meristematic cell with two oblique cutting faces is, however, estab-lished sooner or later (Fig. 19). Rarely it ends in a papilla and in such cases some of the marginal cells lateral to it establish a meristem (Fig. 20). Mostly the apical meristematic cell persists till the gametophyte reaches maturity (Figs. 21, 22) when it is replaced by a meristem (Figs. 23, 24). In a few cases one or two marginal unicellular club-shaped hairs with extra-cellular caps are formed.

The mature gametophyte is cordate (Fig. 26), comparatively small (*cf. Pyrrosia, Platycerium*), broader than long and with a thin midrib. The apical meristem is deep-seated, at the base of the apical notch and consists of 3–4 pyramidal cells (Fig. 25) usually protected by superficial trichomes. Collenchymatous thickenings of the corners (Fig. 27) and a violet hue of the walls occur in the wing cells. Rhizoids are compa-ratively few and have the brownish violet colour of the first rhizoid. Marginal, unicellular, club-shaped hairs with prominent yellowish extra-cellular caps occur sparsely (4–5 per gametophyte). The hair originates towards the centre of the marginal wall of a cell close to the apical meri-stem as a small protuberance which is soon cut off from the parent cell by a basal curved wall. Mature hairs (Figs. 28 *a*, 28 *b*) have a slightly dilated tip covered by a prominent yellowish extra-cellular cap, scanty cytoplasmic contents, a single small nucleus towards the centre and a thin wall. The cap is usually lost in older hairs. Branched hairs (Figs. 29 *a*, 29 *b*) of the type described for *Pyrrosia* (Nayar, 1957) and *Platycerium* (Stokey and Atkinson, 1954) occur superficially on the lower surface, especially over the midrib, curving towards the apex of the prothallus. These hairs also possess prominent extracellular caps but only on the lateral branches. Each hair originates towards the centre of the superficial wall of the parent cell. Appendages are absent on the upper surface.

Antheridia are produced by gametophytes from the spatulate stage of the prothallus onwards. They are on the under-surface, occasionally

extending to the margin. The antheridium is globular and has the usual structure and ontogeny. The opercular cell is single and opens gradually like a hinged lid, finally becoming separated. Archegonia are formed after the formation of antheridia, and both occur together rarely. Archegonial formation lead to initiation of midrib and the superficial hairs. Usually only one sporophyte develops per gametophyte (Fig. 30). The first leaf is simple, entire, spatulate and with a median solitary vein. Simple star hairs (Fig. 31 *a*, 31 *b*) (having one or two arms and a unicellular stalk) with ontogeny and structure similar to those in *Pyrrosia* (Nayar, 1957) develop marginally towards the apex. Branched hairs of the type on the gametophyte occur on the nether surface of the lamina, curving towards the growing apex of the leaf (Fig. 32). The establishment of the reticulate type of venation is as in *Pyrrosia* but the progression stops at the establishment of closed meshes and do not extend to the next stage forming many free ending veinlets as in *Pyrrosia*.

CONCLUSIONS

Drymoglossum has long been recognised as a direct derivative of *Pyrrosia*, though the relationship of the latter genus is in itself a point of dispute among pteridologists. The general morphology of *Drymoglossum* is so strikingly similar to that of *Pyrrosia* that some authors even consider them as one genus. Possession of a thin, elongated, highly branched rhizome denotes primitiveness in *Pyrrosia*, the evolutionary trend being a gradual shortening accompanied by increase in bulk (see Nayar, 1957). Though *Drymoglossum* is generally recognised as a reduced xerophytic derivative of *Pyrrosia* the rhizome retains the most primitive condition and has no adapatations for the xerophytic habitat of the plant. The vascular cylinder is simpler than that of *Pyrrosia* though it is a ' false dictyostele'. The simplicity of the leaf trace is obviously due to the extremely small size of the leaf and the thinness of the rhizome. The origin of the leaf traces is also similar being from different dorsal lateral bundles of the rhizome, as in the latter genus. However, the presence of the double branch trace demarcates *Drymoglossum* from *Pyrrosia* (in which it is invariably single) and tends to go against the suggestion that the former is a reduced derivative of the latter. If reduction has affected the girth of the rhizome and size of the leaf resulting in a decrease in the number of vascular bundles in the former and the extreme simplicity of the leaf traces, it should naturally be expected that the simple nature of the branch trace in *Pyrrosia* is retained in *Drymoglossum*. The possession of two different traces for every branch in *Drymoglossum* denotes a primitive feature where the branch is comparatively a more prominent structure than in *Pyrrosia*. The primitive ferns had equally dichotomising rhizome and on that basis those modern ferns in which the branch is approaching closer to this condition in its comparative importance are more primitive.

Paleæ in being extremely variable in size and some so small as to simulate hairs, though peltate, support the consideration of *Drymoglossum* as comparatively primitive. As in some of the relatively primitive species of *Pyrrosia* (*P. varia*, etc.) there is only one type of stellate

foliar hairs and these are sparse and deciduous, leaving the mature leaf almost glabrous. The leaf itself is fleshy, having special adaptations to conserve water: the undifferentiated mesophyll makes the leaf structure more primitive than that in *Pyrrosia*. In the latter genus more primitive species like *P. varia*, *P. lanceolata*, etc., have epidermal foliar glands lacking or if found, extremely rare, while the more advanced species like *P. fissa*, abound in them. *Drymoglossum* is comparable to the former group.

During ontogeny the leaf of *Pyrrosia* passes through the stage represented by mature leaves of *Drymoglossum* in venation. The extreme case of dimorphism in the latter is a step ahead of the condition in the former, where many species are monomorphic. So also is the acrostichoid distribution of the sporangia in *Drymoglossum*. Notwithstanding these differences the nature of the stomata in the two genera is uniquely similar as also the stellate foliar hairs and their distribution (restricted to the leaf, extending up to the articulation only).

It seems that *Drymoglossum* and *Pyrrosia* are closely related and the former has branched off as a separate line early during the evolution of the latter. The common ancestor of the two might have had a long, creeping, highly branched rhizome, with branches unrelated to leaves and receiving more than one bundle per branch; rhizome with paleæ distributed sparsely and shading off into hairs; prominent phyllopodia articulated to leaves by means of saucer-shaped parenchymatous abscision pads; simple leaf lamina covered by stellate hairs, devoid of epidermal glands but bearing stomata of the *Pyrrosia* type and with undifferentiated mesophyll; monomorphic leaves; sporangia in punctiform sori towards tips of free ending veinlets; sori irregularly scattered on the under-surface and protected by stellate paraphyses; bilateral, monolete, echino-verrucate spores, germinating into a germ tube which occasionally branch and having an irregular growth pattern as in *Pyrrosia adnascens* (Nayar, 1957); a cordate gametophyte bearing rhizoids with a violet hue and with prominent club-shaped marginal hairs and branched superficial hairs; and juvenile leaves with simple lamina and branched hairs. *Drymoglossum* has evolved from this ancestor by xerophytic adaptations, dimorphism of leaf and acrostichoid nature of the sori.

Summary

A phylogenetical evaluation of the morphology of the gametophyte and sporophyte of *Drymoglossum piloselloides* (L.) Presl collected from N.-E. and S.-W. India, is attempted. *Drymoglossum* as here construed is a small genus of epiphytic ferns, of which *D. piloselloides* (L.) Presl (*Pteris piloselloides* L.; *Achrostichium heterophyllum* L.) with its different ' varieties ' is the sole species. The slender, creeping, branched rhizome bears sparsely distributed, peltate paleæ, usually with a dentate margin and acuminate tip. Morphology of paleæ is extremely variable; some of the paleæ are so small as to simulate peltate hairs and some with either an entire or a ciliated margin. Glands are entirely absent and ontogeny is similar to that of *Pyrrosia* Mirbel. Vascular cylinder of the rhizome is a ' false dictyostele ' with

3–4 vascular strands forming a coarse reticulum. Leaf traces are usually single strands originating alternately from lateral bundles on either side of the thick median dorsal bundle. Depending on size of rhizome and that of the leaf concerned, the leaf trace may be as simple as to originate from alternate branches of the median bundle itself. Each trace splits into two before entering the leaf base, the splitting occurring nearer the origin of the trace as the leaf size becomes bigger, so much so that in the biggest leaves the trace at its very origin is double. Branch traces are invariably double, each half originating from separate vascular bundles of the rhizome and fusing together before entering the branch base. Vascular cylinder of rhizome, the leaf-, branch- and root-traces are enveloped in a continuous sheath of cortical sclerenchyma. Leaves are sparse, simple and articulated by a saucer-shaped pad of parenchyma to prominent phyllopodia covered by paleæ. Foliar appendages are stellate hairs of the *Pyrrosia*-type. Venation is reticulate with branched vein endings included in the meshes. Lamina is fleshy, lack epidermal glands and is composed of parenchyma cells with bellows-like walls which collapse during wilting. Fertile leaves are linear with acrostichoid distribution of the sori intermixed with stellate paraphyses. Sporangial stalk is 3 cells thick and annulus is 14–19 cells long abutting on a 4-celled stomium. Spores are bilateral and with an echino-verrucate exine. The germ tube becomes 4–6 cells long when flattening occurs, by division of all anterior cells, resulting in a spatulate prothallus devoid of any definite meristem. A 3-sided apical cell is established soon and thereafter the development is of usual type resulting in a cordate thin prothallus bearing sex organs of the usual type. Rarely the apical cell ends in a papilla and the growth is continued by a meristem established lateral to it. All rhizoids possess a violet brown colour. Cells of the prothallus have collenchymatous thickenings of corners and a pale violet colouration of walls. Sparse, unicellular, club-shaped hairs with extra-cellular caps, and branched superficial hairs occur on mature gametophytes. The first juvenile leaf is simple with a median unbranched vein and the progression to the adult stage of venation is as in *Pyrrosia*. It is concluded that, contrary to the current conception, *Drymoglossum* may not be a direct descendant of *Pyrrosia*, but may have branched off from a common ancestor during the evolution of the latter genus.

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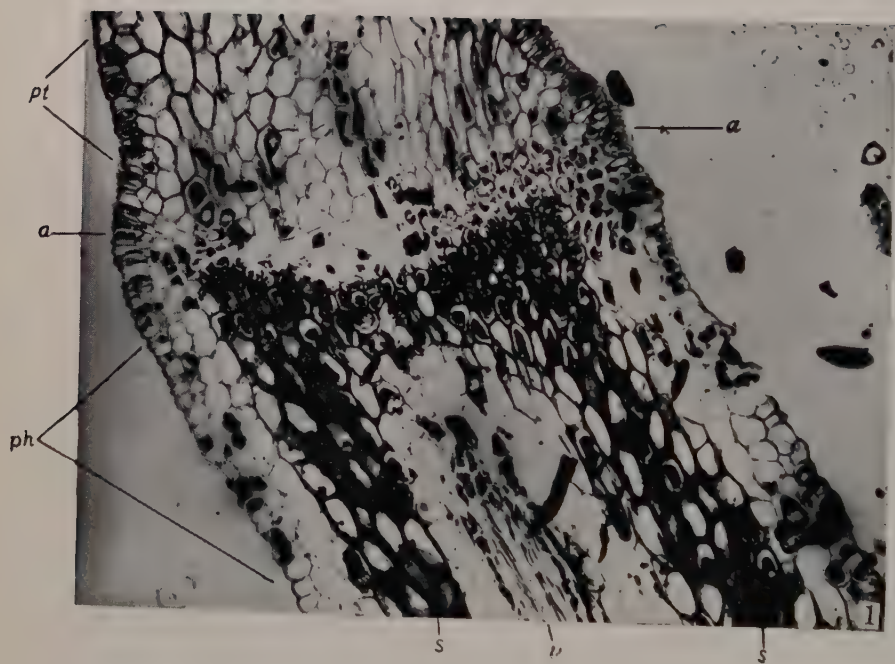
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EXPLANATION OF PLATE VI

FIG. 6. Photomicrograph of l.s. of phyllopodium showing region of articulation to petiole; *a.*, articulation; *ph.*, phyllopodium; *pt.*, petiole; *s.*, cortical sclerenchyma sheath; *v.*, vascular bundle.

THE MORPHOGENETIC EFFECTS OF VARIOUS SYNTHETIC HORMONES ON THE LIVERWORT *LUNULARIA*[1]

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WE had discovered that the gemmæ of *Lunularia cruciata* are exceedingly sensitive to the influences of various physical and chemical factors (Narayanaswami and La Rue, 1955; La Rue and Narayanaswami, 1955). The growth patterns formed in response to these factors are extremely varied and unusual. In our earlier work we also found that growth hormones were among the chemical factors of greatest morphogenetic potential and that indoleacetic acid is formed in the tips of the thalli of *Lunularia* (La Rue and Narayanaswami, 1957). This hormone is present in sufficient amount to inhibit germination of the gemmæ in the gemma-cups and to prevent the formation of adventitious buds in the thalli. Rousseau (1951) had previously shown that growth hormones produced growth effects in the liverwort thalli. When Prof. F. G. Gustafson supplied Prof. La Rue with a number of unusual hormones which Dow Chemical Company had furnished him for study, it was decided to survey the effects of these substances on the growing gemmæ and thalli of *Lunularia*.

MATERIAL AND METHODS

Gemma-cup-bearing thalli of *Lunularia* were obtained from the greenhouse of the University of Michigan Botanical Gardens and kept in damp chambers until needed. Gemmæ were removed from the cups and spread on filter paper wet with White's solution (1943) for controls, or with hormone solutions. After treatment, the filter papers with their gemmæ were laid on sand in petri dishes and the gemmæ allowed to grow in a greenhouse exposed to north light. The gemmæ were irrigated from time to time with the test solutions.

Mature thalli selected for experimentation were lifted with slabs of earth adherent to their lower surfaces and put in petri dishes and kept moist in the greenhouse.

EXPERIMENTAL RESULTS

A. Treatments of gemmæ

Indoleacetic acid.—Gemmæ treated with a solution of IAA, 10^{-2} M, promptly died. A group of gemmæ was submerged in a solution of

IAA, 10^{-3} M and the air was exhausted from the solution for 15 minutes in an attempt to secure penetration of the hormone into the gemmæ. Growth was maintained on White's solution for 3 weeks. Cylindrical buds were usually formed between growing points of the gemmæ and these gave rise to attenuated and irregular upright expanded lobes (Fig. 1, *a–e*).

A dosage with IAA, 10^{-5} M caused a similar effect but the thalli were wider (Fig. 2).

Gemmæ treated with IAA, 5×10^{-6} M and grown for eight weeks showed no adventitious buds at all but formed long ribbon-like thalli which showed a peculiar bend about midway of their length (Fig. 3, *a, b*).

A treatment with IAA, $0 \cdot 1\%$ for 10 days followed by growth on White's solution for one week showed a complete inhibition of almost all normal growing points. The gemmæ expanded irregularly and gave rise to adventitious buds on both upper and lower surfaces. These grew into succulent upright lobes which soon started expansion of their tops into thalli ('*feet*') (Fig. 4, *a–f*).

Treatment with IAA, $0 \cdot 25\%$ for 12 hours gave results almost identical with the $0 \cdot 1 \%$ solution for 10 days (Fig. 5, *a, b*).

A dosage of IAA, 10^{-6} M combined with one of NAA, 10^{-3} M in equal proportions and continued for 3 weeks, showed an almost complete inhibition of growing points but no formation of any adventitious bud. The only growth was an irregular expansion of the body of the gemma (Fig. 6, *a-c*) which later became succulent and produced rhizoids sporadically but no buds.

One lot of gemmæ was grown on a mixture of equal parts of IAA, 5×10^{-5} M and adenine sulphate, 5×10^{-5} M for 4 weeks. Upright, cylindrical, succulent lobes were formed adventitiously on both upper and lower surfaces, and a few arose from the growing points also (Fig. 7, *a–c*). Adenine sulphate, alone, allowed better growth and broader thalli in concentrations of 10^{-4} M and 10^{-5} M.

Solutions of IAA, 10^{-2} M + NAA, 10^{-3} M; IAA, 10^{-2} M + NAA, 10^{-6} M; IAA, 10^{-2} M + IBA, 10^{-3} M and IAA, 10^{-6} M + NAA, 10^{-3} M inhibited growth of growing points, practically prevented any growth of gemmæ, prevented the development of any adventitious bud and allowed growth of only rhizoids which developed in groups just back of the growing points on upper and lower surfaces of the gemma (Fig. 8).

IAA, 5×10^{-5} M + NAA, 10^{-3} M gave results similar to those recorded in the preceding paragraph but allowed the development of succulence in the gemmæ. However, IAA, 5×10^{-5} M + NAA, 10^{-2} M; IAA, 10^{-4} M + NAA, 10^{-2} M and IAA, 10^{-3} M + NAA, 10^{-2} M caused the death of all the gemmæ treated.

Indolebutyric acid.—Treatment of gemmæ with a solution of IBA, 10^{-2} M quickly resulted in the death of all the subjects.
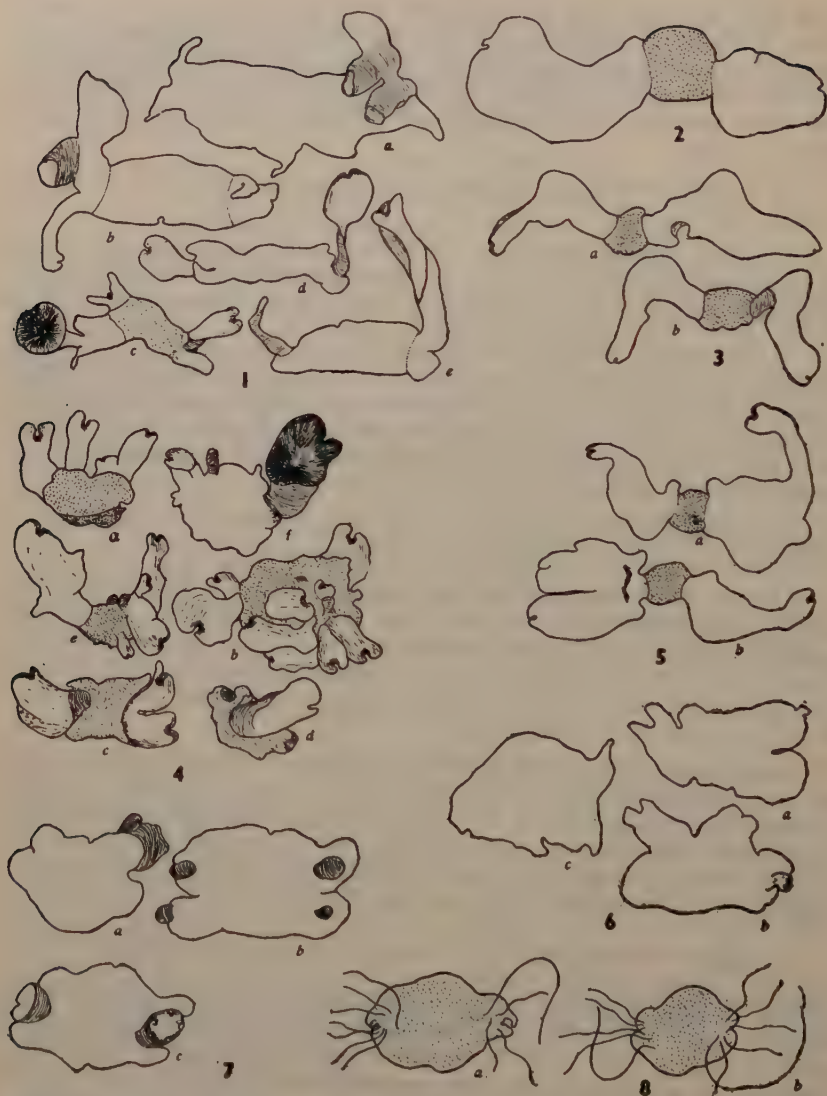
TEXT-FIGS. 1–8. Fig. 1, *a–e*. Effect of exhaustion on gemmæ suspended in a solution of IAA, 10^{-3} M for 15 minutes and later grown on a solution of mineral elements alone. for 3 weeks. Fig. 2. Growth of gemmæ with IAA, 10^{-5} M. Fig. 3, *a, b*. Same as above, with IAA, 5×10^{-6} M. Fig. 4, *a–f*. Gemmæ treated with 0·1 per cent. solution for 10 days and then on a solution of mineral elements alone. Fig. 5, *a, b*. Effect of soaking gemmæ in IAA, 0·25 per cent. solution for 12 hours and then grown in White's solution for 2 weeks. Fig. 6, *a–c*. Gemmæ grown in a mixture of IAA, 10^{-6} M + NAA, 10^{-3} M, equal parts for 3 weeks. Fig. 7, *a–c*. Same as above, with IAA, 5×10^{-5} M + adenine sulphate, 5×10^{-5} M, in equal parts. Fig. 8, *a, b*. Same as above, with IBA, 10^{-3} M + NAA 10^{-3} M and grown for 3 weeks. All, $\times 14$, except Fig. 3 which is $\times 7$.
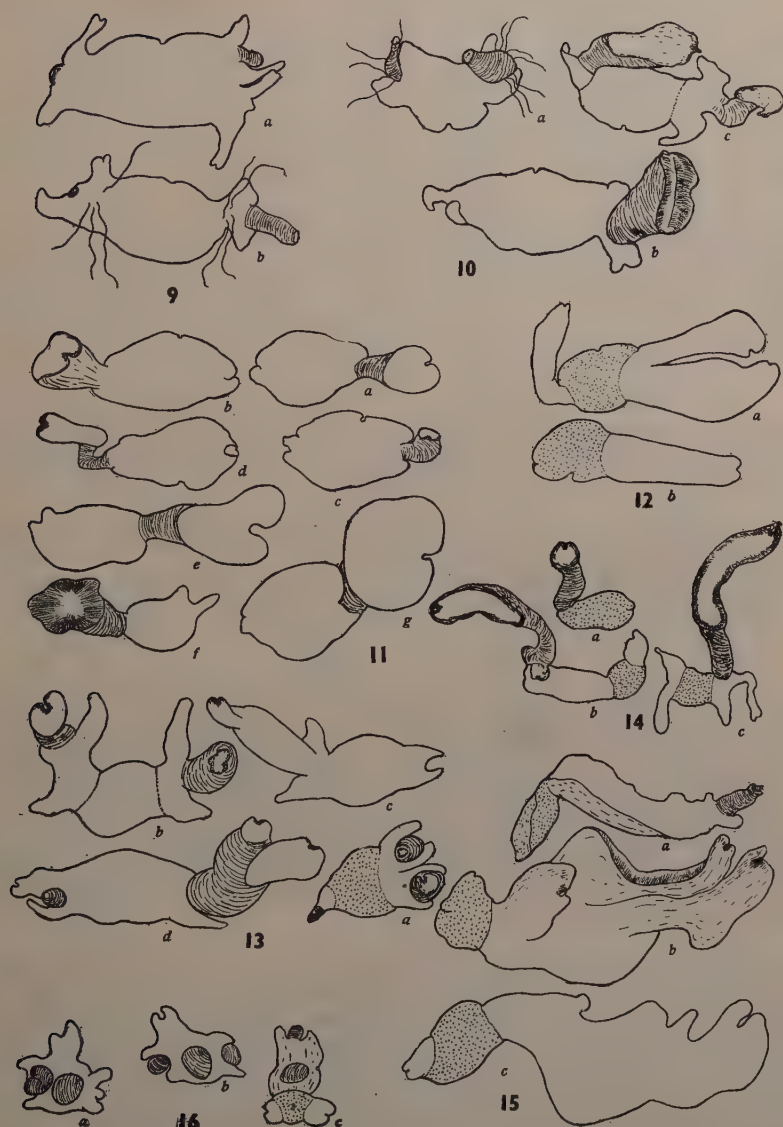
TEXT-FIGS. 9–16. Growth effects on gemmæ treated with various concentrations of IBA and later transferred to White's solution (control). Fig. 9, *a, b*. Effect of IBA, 10⁻³ M grown for 10 days. Fig. 10, *a–c*. Same as above, grown for 2 weeks. Fig. 11, *a–g*. Same as above, grown for 4 weeks. Fig. 12, *a, b*. Gemmæ suspended in a solution of IBA, 10⁻³ M and exhausted for 20 minutes and then grown in a solution of mineral elements alone. Fig. 13, *a–d*. Effect of IBA, 0·1 per cent, for 3 weeks and then on White's solution alone for 2 weeks. Fig. 14, *a–c*. Same as above, with IBA, 0·25 per cent. Fig. 15, *a–c*. Same with IBA, 10⁻ M. Fig 16, *a–c*. Gemmæ grown in a mixture of equal parts of IBA, 0·1 per cent. NAA, 0·1 per cent, for 3 weeks. All, ×15.

Gemmæ grown in a solution of IBA, 10^{-3} M for 10 days grew extensively and formed long, divergent lobes (Fig. 9, a). Some gave abundant growths of rhizoids near the growing points (Fig. 9, b). A similar treatment for two weeks showed further irregularities and increases in size and complexity of the cylindrical upright lobes (Fig. 10, a) many of which showed *splitting* (Fig. 10, b) and flattening of the upper ends forming ' feet ' (Fig. 10, c). Further growth showed a tendency for the tips of the upright lobes to differentiate into thalli (Fig. 11, a–g).

When gemmæ were put in a solution of IBA, 10^{-3} M and air was exhausted with an aspirator for 20 minutes followed by growth on White's solution for 2 weeks, growth appeared to be somewhat depressed both in the gemmæ and in the thickened lobes which grew out from the growing points (Fig. 12, a, b). The latter appeared pale yellow and the individual cells showed considerable elongation.

A treatment with IBA, $0 \cdot 1\%$ for 3 weeks with subsequent growth on White's solution resulted in peculiar elongations and greater variations in the divergent auricles of the gemmæ (Fig. 13, a–c) and unusual growth and branching of the upright lobes (Fig. 13, c, d).

A treatment with IBA, $0 \cdot 25\%$ for 2 weeks with subsequent growth on White's solution produced very peculiar elongations of the upper ends of the upright lobes (Fig. 14 a, c). Further aberrations of the upright lobes were produced by treatments with IBA, 10^{-4} M and growth for 4 weeks (Fig. 15, a–c).

Growth in a mixture of IBA, $0 \cdot 1\%$ and NAA, $0 \cdot 1\%$ for three weeks gave rise to great irregularity in the gemmæ themselves. Apparently the usual dominance of the growing points was destroyed and adventitious spherical buds were formed at random on the upper surface of the gemmæ (Fig. 16, a–c). When concentrations of IBA and NAA were reduced to half of that used in the preceding test, growth from the growing points was noticeably delayed but spherical buds did form (Fig. 17, a, b). The gemmæ themselves grew unusually long and the auricles grew into extended slender lobes crossing each other in contrast to subjects of the higher dosage.

Naphthaleneacetic acid.—A concentration of 10^{-2} M of the hormone killed all the gemmæ subjected to it. When a strength of NAA, 10^{-3} M was used, at least 25% of the treated gemmæ survived. The body of the gemmæ increased in size and many rhizoids were formed on the thalli immediately behind the growing points. No adventitious buds grew out and the growing points were inhibited. Weaker solutions did not show any appreciable effects on the growth of thalli from the gemmæ (Fig. 18, a, b).

A solution of $0 \cdot 1\%$ caused the death of nearly all but not all the gemmæ. However, no growth took place in the surviving ones.

Phenylbutyric acid.—Only one concentration of 10^{-3} M of the test chemical was tried. Some growth of the treated gemmæ resulted. Flat or cylindrical supernumerary outgrowths were induced at the growing

TEXT-FIGS. 17–24. Fig. 17, *a, b*. Gemmae grown for 3 weeks in a mixture of equal parts of IBA, 0·05 per cent. and NAA, 0·05 per cent. Fig. 18, *a–b*. Same as above, with NAA, 0·01 per cent. Fig. 19, *a–e*. Growth effects on gemmæ treated with phenylbutyric acid, 10^{-3} M for 2 weeks. Fig. 20, *a–c*. Same as above, with 4-chloro-*o*-toloxyacetic acid, 0·05 per cent. for 2 weeks. Fig. 21, *a–d*. Same as above, with dinitro-*o*-sec-butyl phenol (a dilute solution), grown for 4 weeks. Fig. 22, *a–e*. Effect of 2, 4–5 trichlorophenoxyacetic acid, 0·1 per cent, grown for 2 weeks. Fig. 23, *a–d*. Effect of α-(*o*-chlorophenoxy) propionic acid, 0·05 per cent, for 1 week and then on control for 10 days. Fig. 24, *a–d*. Effect of *o*-chlorophenoxyacetic acid : *a, b* with 0·1 per cent, for 48 hours and then on the control for 10 days, ×15 ; *c, d*, 0·05 per cent. for 10 days and on control for 10 days, ×7. All, ×15.

points (Fig. 19, *a–e*). The upper end of these developed into normal thallus.

4-chloro-o-toloxyacetic acid.—Gemmæ were treated with 0·05% solution for 10 days and were then grown on White's solution. They became succulent with margins very much fringed (Fig. 20, *a–c*). Cylindrical buds originated either from the surfaces or between the auricles or from the fringed margin. Warty outgrowths from the surface of the gemmæ were also observed. Rhizoidal groups were produced near the apices (Fig. 20, *c*).

Dinitro-o-sec-butyl phenol.—Concentration used was 1 drop in 30 c.c. of water. The auricles of the gemmæ were drawn out into lobes which were narrow or rounded and blunt, and very much thickened (Fig. 21, *a–d*). Buds formed at the apical notches became elongated, cylindrical stalk-like structures which later expanded at the tip to form normal thalli recalling the ' feet ' or the ' cups ' (Fig. 21).

2, 4–5-Trichlorophenoxyacetic acid.—Treated with 0·1% solution, the gemmæ turned brown in about two weeks indicating death. A few that survived were succulent and puffed up (Fig. 22, *a*) like a bun or were elongated (Fig. 22, *b*). The auricular lobes were drawn out, pale and narrow or blunt and thick, and reflexed (Fig. 22, *c–e*).

Treatment with still lower concentrations of the hormone caused peripheral portions of the gemmæ to turn brown while the central portion remained alive and capable of regeneration. Bud formation from the growing ends were inhibited. Groups of rhizoids developed from the upper surface of the gemmæ.

α-(o-Chlorophenoxy) propionic acid.—Gemmæ were treated with 0·1% solution of the chemical for one week and were then grown on White's solution for another week. The fresh thallus tips were either forked (Fig. 23, *a, b*) or showed *splitting*, the split lobes being broad and vigorously growing (Fig. 23, *c*). The buds arising between the auricles grew upright and broadened out into thalli, making 'feet' (Fig. 23, *d*).

o-Chlorophenoxyacetic acid.—Treatment with 0·1% solution for 48 hours and then grown in White's solution, caused considerable elongation of body of the gemmæ (Fig. 24, *a, b*) which later developed spherical buds between the auricles. Grown in a solution half the strength, numerous adventitious buds arose from the growing points and from undersurface of the gemmæ (Fig. 24, *c, d*).

Treatments with *p*-chlorophenoxyacetic acid gave similar results.

B. *Treatments of thallus*

Indolebutyric acid, 0·1%.—Normal growth of thalli was affected. A reduction in size of the new tips arising from the apical notches was observed (Fig. 25, *a*). Treatment of gemma-cup-bearing thalli for 2 weeks resulted in the formation of bowls by the gemma cups, the margins of which had considerably grown out. Rhizoids were produced in abundance on the upper surface. Upright, cylindrical outgrowths

developed from the growing points, later forming 'feet' at their apices (Fig. 25 *b*).

2, 4-*Dichlorophenoxyacetic acid.*—Thalli grown in 0·1% solution for over a month showed a new spurt of growth from their apices. These were somewhat narrow and canoe-shaped. Spherical masses of green tissue were formed on the young thalli. Adventitious buds were also produced from within the gemma cups.

In a mixture of IBA, 10^{-4} M and 2, 4-D of the same concentration, the thallus tips grew out into twisted irregular shapes and were pebbly in appearance. Green callus tissue with knob-like protuberances were formed at their apex accompanied by rhizoid formation.

The growth effects with IAA were almost identical with those of IBA.
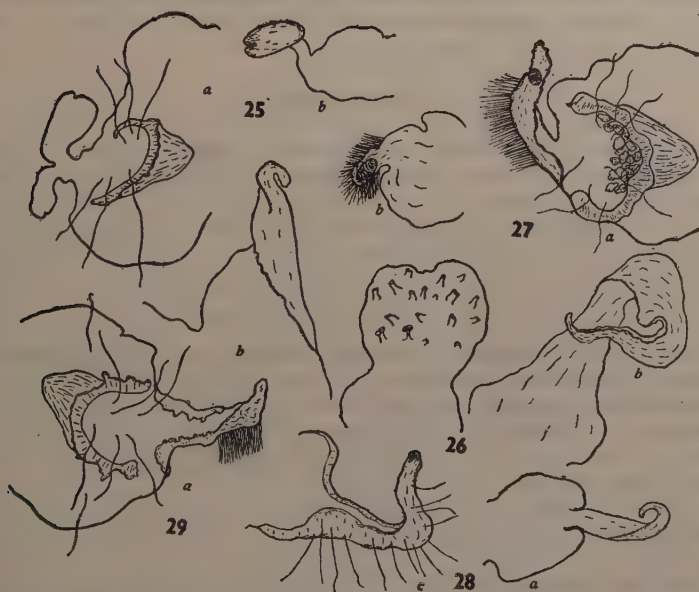
TEXT-FIGS. 25–29. Effect of growth substances on thalli, treated for 3 weeks. Fig. 25, *a, b.* Effect on thallus growth with IBA, 0·2 per cent. Fig. 26. Same as above, with NAA, 0·1 per cent. Fig. 27, *a, b.* Effect of α-(*o*-chlorophenoxy) propionic acid, 0·1 per cent. Fig. 28, *a–c.* Same as above, with *o*-chlorophenoxyacetic acid, 0·1 per cent. Fig. 29, *a, b.* Effect of 2, 4–5 trichlorophenoxyacetic acid, 0·1 per cent. All, ×42.

NAA, 0·01%.—Thalli irrigated from time to time with a solution of this hormone caused a broadening of the thallus tips (Fig. 26). The pores nearer the apex were elongated standing upright and pyramidal in shape and their cells were considerably enlarged. Rhizoids arose from the upper surface of the thalli and from within the gemma cups. Remarkably wide pit-like depressions were observed in the region of the growing points exposing the dark green chlorophyllous filaments.

α-O-*chlorophenoxypropionic acid.*—Growth of thalli in 0·1% solution of this hormone caused an abrupt narrowing of the apical growths into strongly concave procumbent structures (Fig. 27, *a*) on which spherical masses of green tissue (Fig. 27, *a*, *b*) as in treatments with 2, 4-D were formed. Ephemeral rhizoids were induced from within the gemma cups the margin of which had grown out into flaps.

O-*chlorophenoxyacetic acid*, 0·1%.—The normal growth of thalli was inhibited and a new spurt of growth was observed from the apical notches. The regenerated thalli were considerably elongated and bent like a trumpet with the tips narrowed down to a point (Fig. 28, *c*). The margin of the fresh thalli tended to fold along the midrib.

2, 4–5-*Trichlorophenoxyacetic acid, dilute solution.*—The gemma cups showed considerable growth. The margin of the cups was fringed and reflexed backwards accompanied by formation of ephemeral rhizoids from within the gemma cups (Fig. 29). The thallus grew into a semicircular loop with toothed margin.

CONCLUSIONS

Gemmæ were lifted out of their cups and grown in various solutions of the hormones in different concentrations for varying periods. Some of them after having been grown for a time in a solution of the growth hormone, have subsequently been transferred to a basal medium of mineral elements alone (White, 1943) which was used as the control. In general, higher concentrations of the hormones caused inhibition of the normal growth of thalli from the growing points.

The immediate effect of treatment with IAA in dilute solutions is to stimulate abundant production of adventitious thalli from almost any portion of the gemma but more so towards the growing ends. This was similar to the effect of plasmolysis reported by Nagai (1919) and La Rue and Narayanaswami (1955). Cylindrical buds developing ' feet ' or 'cups' were also observed. Gemmæ soaked in a solution of IAA for a time and later grown on a solution of mineral elements alone, however, did not induce any accessory buds.

A point of some interest was that solutions of IAA, IBA and NAA in high concentrations caused the death of all the subjects. But in combination with other hormones in appropriate concentrations, most gemmæ seemed to survive although inhibited in their growth. This would indicate synergistic action of the hormones although this observation requires to be corroborated by further experimentation.

IBA caused inhibition of growth of normal thalli in high dosages but resulted in the formation of spherical or cylindrical buds between the notches when returned to a basal medium without the hormone. A tendency for branching was also apparent. Incipient splitting was occasionally observed. Weaker concentrations of the hormone did not appreciably affect the normal morphological pattern of thallus development except for the production of a few extra thalli.

Inhibition of apical growth resulted in the development of buds from the surface of the gemma body in treatments with the different hormones for a time and their subsequent transfer, to the basal medium which was used as the control. Hormone applications, in general, appear to cause the following effects on gemma growth depending on the strength of the solution used:—

(*a*) development of adventitious thalli,

(*b*) removal of apical dominance resulting in the formation of adventitious buds from the general surface (plasmolysis effect),

(*c*) inhibition of normal growth of thalli from growing points,

(*d*) expansion of the body of the gemmæ,

(*e*) absence of ' splitting ' which caused the thalli to branch in a peculiar manner (La Rue and Narayanaswami, 1954).

Hormone treatments of growing thalli caused an abrupt narrowing of the thallus tips. The gemma cups grew into bowls. Their margins were fringed and reflexed as a flap. The pores were raised above the thallus surface as hollow tubes or funnels and rhizoids were abundant on gemma body and within the gemma cups.

It would be interesting to recall in this connection our earlier observation (La Rue and Narayanaswami, 1955) of the formation of upright, cylindrical buds growing into *feet* with treatments of 2, 4-D and other substances. Buds, not from the growing points, but elsewhere on the gemma were induced by treatments of polyploidising agents like colchicine and sodium cacodylate. Actidione, an antibiotic, caused the formation of great numbers of such buds; so also treatments of IAA and phenylbutyric acid. No permanent effects were provided by hormone applications as evidenced by the resumption of normal growth in solutions of the mineral elements alone.

Narayanaswami and La Rue (1955) had explained plasmolysis as a strong morphogenetic factor in inducing accessory buds from the surface of the gemma as a consequence of the removal of apical dominance. In the present investigation it would appear that the formation of accessory buds is stimulated by the application of appropriate concentrations of hormones and not as a result of the removal of apical inhibition. With higher doses of the hormones it is possible that there is some inhibition for a time with subsequent loss of inhibition resulting in the formation of upright, cylindrical lobes which later develop normal, expanded, dorsiventral thalli.

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CYTO-TAXONOMIC STUDIES IN THE GENUS *RICCIA* (MICH.) L.

I. *R. billardieri* Mont. et N. and *R. gangetica* Ahmad*

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INTRODUCTION

CYTOLOGICAL and cultural investigations on the genus *Riccia* have greatly facilitated to settle the taxonomic confusion that prevailed in the past, particularly with respect to the *R. fluitans*-complex. Notable researches by Lorbeer (1934) and Müller (1940, 1941) have shown, for example, that from *R. fluitans*-complex could be segregated four distinct species, viz., *R. fluitans* ($n = 8$), *R. rhenana* ($n = 16$), *R. duplex* ($n = 16$) and *R. canaliculata* ($n = 8$). These observations were subsequently confirmed by Meijer (1951). In India a somewhat similar confusion persisted for a long time with respect to the *R. himalayensis*-complex which has been broken up into *R. discolor*, *R. billardieri* and *R. gangetica* mainly on critical taxonomic details (Udar, 1957 *a*). With a view to settle the issue finally a cytological investigation of the above species together with all the other species of the genus growing in the country was taken up at the suggestion of Dr. S. K. Pandé.

Cytological investigation of the genus *Riccia* has received relatively little attention in India. Srinivasan (1940), who described the cytology of the monœcious *R. himalayensis*, reported the haploid number of the chromosomes as eight, seven of which are rod-shaped and the eighth is dot-like. The latter was always observed to lie in the centre of the rods but he made no reference to the significance of this dot-like complement. Mahabale and Gorji (1941) described the cytology of a species of *Riccia*, referred by them as *R. himalayensis*, and observed a similar pattern and number of chromosomes as reported by Srinivasan (1940). The taxonomic limits of *R. himalayensis* were vaguely defined at the time its cytology was worked out, hence the results obtained cannot be much relied upon. The cytology of the *R. himalayensis*-complex, therefore, needs reinvestigation in the light of its segregates (Udar, 1957 *a*). Later Mahabale (1942) reviewed the data available on the cytology of the liverworts and gave the basic haploid number of chromosomes in Ricciaceæ as eight. In a subsequent paper Mahabale and Gorji (1947) gave the chromosome numbers in both *R. sanguinea* (a synonym of *R. frostii*) and *R. discolor* as eight, seven of which are more or less V-shaped and the eighth is a small dot-like body. Kachroo (1955) listed the chromosome numbers in four species, *viz.*, *R. discolor* ($n = 8$), *R. crystallina*

($n = 8$), R. cruciata ($n = 16$) and R. melanospora ($n = 16$). The observations of Kachroo on the chromosome number in R. crystallina ($n = 8$) do not conform with ($n = 4$) given earlier by Lewis (1906).

The present communication deals with the cytology of R. billardieri and R. gangetica, the two common monsoon species of Riccia growing abundantly in seve.al parts of India. The taxonomic features of these species growing in the country have been given by Udar (1957 a, b).

MATERIAL AND METHOD

Plants of R. billardieri and R. gangetica were collected locally from the Lucknow Residency and the Isabella Thoburn College compounds. Younger plants maintained under culture in the laboratory were also utilised. The material was fixed in acetic-alcohol (1 : 3). Squash preparations were used exclusively in this study. Gametophytic chromosomes were obtained from the tissues of the thallus particularly at the apical region. Capsules were also squashed. Aceto-carmine was used for staining. The temporary squashes of both the gameto-phytic tissues and spore-mother cells were examined and figures were drawn within the first two days. Subsequently they were made perma-nent in the usual way.

The best time of fixation for cytological investigations in these two species is between 10 A.M. to 12 NOON.

OBSERVATIONS

Riccia billardieri Mont. et N.

In several aceto-carmine thallus squashes 8 chromosomes (Fig. 1) were counted at metaphase (polar view). The chromosomes are

0·025 mm
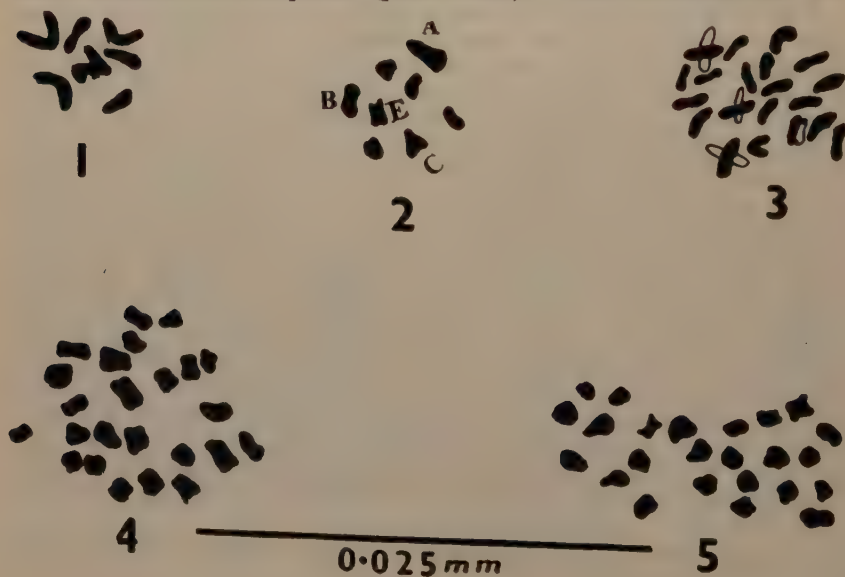
FIGS. 1—5.

TEXT-FIGS. 1–5. Figs. 1–2. *Riccia billardieri*. Fig. 1. 8 mitotic chromosomes at metaphase (polar view). Fig. 2. 8 bivalents at diakinesis. Figs. 3–5. *Riccia gangetica*. Fig. 3. 24 mitotic chromosomes at metaphase (polar view). Fig. 4. 24 bivalents at diakinesis. Fig. 5. 24 bivalents at Metaphase I.

variable in size and form; four of these are V-shaped and four are rod-shaped. Among the four V-shaped chromosomes one is smaller than the rest. The species is monœcious and apparently there is no sex-chromosome.

In aceto-carmine capsule squashes eight bivalents were counted at diakinesis (Fig. 2). Three of these bivalents (A, B and C) are larger in the descending order and among these two (A and B) are in the form of rods. The third one (C) and also (E) show cross-chiasma. Meiosis is normal.

Riccia gangetica Ahmad

In aceto-carmine thallus squashes 24 chromosomes were counted at metaphase (Fig. 3) and in aceto-carmine capsule squashes 24 bivalents were counted at diakinesis and metaphase I (Figs. 4, 5). Meiosis was followed and no laggards were observed where diad and tetrad nuclei are in the process of formation.

DISCUSSION

As will be evident from the table given below the number of chromosomes given by various authors in the genus *Riccia* shows a good deal of variation:—

Name of the species		n	$2n$		Authors
R. crystallina	..	4	×		Lewis (1906)
R. crystallina	..	8	16		Siler (1934)
R. crystallina	..	8	×		Kachroo (1955); Vanden Berghen (1955)
R. natans	..	9	×		Siler (1934)
R. austinii	..	9	×		,,
R. sullivanti	..	8	×		,,
R. sorocarpa	..	8	×		,, and Vanden Berghen (1955)
R. arvensis	..	8	×		Siler (1934)
R. campbelliana	..	8	×		,, ,,
R. californica	..	9	×		,, ,,
R. trichocarpa	..	8	×		,, ,,
R. donnellii	..	8–16	×		,, ,,
R. gaugetiana (diploid gametophyte)		18	×		,, ,,
R. canaliculata	..	8	×		Lorbeer (1934), Meijer (1951) and Vanden Berghen (1955)
R. fluitans	..	8	×		,,

Name of the species	n	$2n$	Authors
R. glauca	9	×	Heitz (1927) and Vanden Berghen (1955)
R. glauca	8	×	Wentzel (1929) and Johansen (1934)
R. glauca	7 or 8	×	Beer (1906)
R. ciliata	8	×	Vanden Berghen (1955)
R. bifurca	8	×	,,
R. beyrichiana ..	8	×	,,
R. duplex	16	×	Vanden Berghen and Meijer (1951)
R. rhenana	16	×	Lorbeer (1934) and Meijer (1951)
R. himalayensis ..	8	16	Srinivasan (1940) and Mahabale and Gorji (1941)
R. discolor ..	8	×	Mahabale and Gorji (1947) and Kachroo (1955)
R. frostii ..	8	×	Mahabale and Gorji (1947)
R. cruciata	16	×	Kachroo (1955)
R. melanospora ..	16	×	,, ,,
R. billardieri ..	8	16	Udar and Chopra
R. gangetica ..	24	48	,,

It would be evident from the table that 17 spp. show the chromosome number $n = 8$ which, in all probability, represents the basic number for the genus. The number $n = 16$ for five species would suggest that the species in question are diploids. The number $n = 9$ may be due to fragmentation or it may be that one of the chromosomes disjuncted precociously and resulted in an error in counting. The latter view has been clearly shown for *R. glauca* by Johansen (1934). $n = 24$, as observed by the authors in *R. gangetica*, has not been so far reported for any other species of the genus. It is probable that this polyploid (hexaploid) species has originated in the evolution of the species in the genus *Riccia*.

SUMMARY

1. *Riccia billardieri* is monœcious.

2. The haploid and diploid numbers of chromosomes for this species is 8 and 16 respectively. Meiosis is normal.

3. *Riccia gangetica* is monœcious.

4. The haploid and diploid numbers of chromosomes for this species is 24 and 48 respectively. Evidently this polyploid species has originated in the evolution of the species in the genus *Riccia*. Meiosis is normal.

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* Not seen in original.

THE PEZIZACEÆ OF THE MUSSOORIE HILLS—II

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This paper is intended to record more Pezizaceæ from the Mussoorie Hills (5,000–7,500 feet altitude in the North-Western Himalayas) as a part of the study of the Fungal Flora of that region undertaken by the senior author and his students (Thind and Batra, 1956). Of the 7 species of Pezizaceæ described here, 6 are new records for India while new combinations are proposed for 2 species.

The numbers of the species are the serial numbers of the Pezizoid Flora.

Type collections have been deposited in the Herbarium of the Panjab University. Duplicate material is at the Mycological Collections of the Bureau of Plant Industry, Beltsville, Maryland, U.S.A.

8. *Sphærospora brunnea* (Alb. & Schw. ex Fr.) Mass., *Brit. Fungus—Fl.,* 4: 295, 1895.

Apothecia up to 6 mm. in diameter, gregarious to very much crowded to form congested masses covering several centimetres of the substratum, sessile, at first globose, later expanding and becoming discoid, mostly contorted due to mutual compression, fleshy, brittle; external surface brown, hairy; hairs up to $200 \times 12\,\mu$, short, erect, light brown, rounded at the top when young, later becoming sharp-pointed at the top, arranged in fascicles, unbranched, septate, septa up to 4; margin hairy, elevated due to mutual compression; hymenium slightly darker than the external surface, concave to plane, smooth.

Asci $188–245 \times 13–16\,\mu$, cylindrical, apex rounded, tapering below into a stem-like base, bulging out opposite to the mature spores, not turning blue with iodine solution.

Ascospores $12–17\,\mu$ in diameter, 8 in number, 1–7 spores may be aborted, uniseriate, subhyaline, globose, smooth, uniguttulate, guttule large and filling three-fourths of the spore cavity.

Paraphyses up to $263 \times 3 \cdot 5\,\mu$, reaching a diameter of $7\,\mu$ at the top, brownish, clavate, simple, or branched near the base, enlarged at the top, septate (Text-Fig. 1, A–C).

Collected on burnt soil and charcoal pieces in charcoal preparation beds, Jabber Khet, Mussoorie, August 1, 1952, **133**. On burnt soil
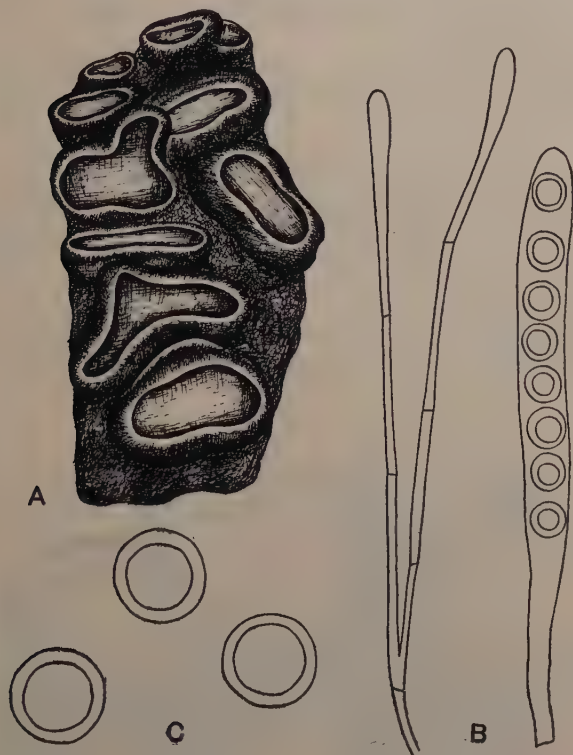
TEXT-FIG. 1. *Sphærospora brunnea* (Alb. & Schw. ex Fr.) Mass. A. Apothecia congested together, ×6. B. Ascus and paraphyses, ×400. C. Smooth and uniguttulate ascospores, ×950.

and charcoal pieces in charcoal preparation beds, The Park, Mussoorie, August 20, 1954, **134**. New record in India.

This species is quite common in the Mussoorie Hills and is cha racterized by smaller apothecia forming congested masses on burnt places and smooth, uniguttulate ascospores.

9. *Lamprospora trachycarpa* (Curr.) Seaver, *Mycologia*, **6**: 19, 1914.

Syn. : *Peziza trachycarpa* Curr. *Trans. Linn. Soc.*, **24**: 493, 1864.

Detonia trachycarpa Sacc. *Syll. Fung.*, **8**: 105, 1889.

Phæopezia scabrosa Sacc., *Syll. Fung.*, **8**: 472, 1889.

Apothecia from a few mm. to 1 cm. in diameter, gregarious, or forming congested masses extending over several centimetres, discoid or shallow cup-shaped, regular, or irregular due to mutual compression, essile, or narrowed below into a stem-like base, brown, fleshy, brittle; xternal surface rough due to the presence of numerous tubercles, light

brown; margin wavy; hymenium plane or concave, brown, darker than the external surface.

Asci 280–325 × 18–20 μ, cylindrical, apex rounded, tapering below into a short stem-like base.

Ascospores 14–17 μ in diameter, 8 in number, irregularly arranged when young, later becoming uniseriate, brown, globose, smooth at first, profusely and prominently verrucose at maturity, warts coarse, up to 1·5 μ long, uniguttulate, guttule large and filling almost whole of the spore cavity.

Paraphyses 280–300 × 3–4 μ, up to 9 μ wide at the top, brown, unbranched, septate, much enlarged at the top (Text-Fig. 2, A–C).
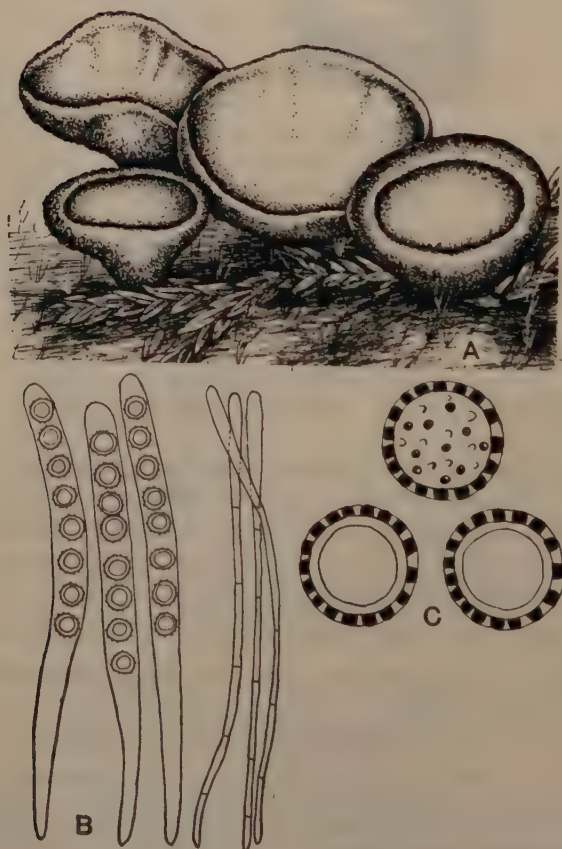
TEXT-FIG. 2. *Lamprospora trachycarpa* (Curr.) Seaver. A. Apothecia, ×5. B. Asci and paraphyses, ×200. C. Prominently verrucose ascospores. ×950.

Collected on charcoal preparation places in Oak forest, Jabber Khet, Mussoorie, September 12, 1952, **135**. New record in India.

The species is marked by brown apothecia forming gregarious masses on burnt soil, rough external urface, and brown, globose, prominently verrucose ascospores with a large guttule. Apparently the large guttules present in the ascospores in this Mussoorie collection (*n.* 135) do not appear to have been noted by Boudier (*Ic. Myc.*, pl. 305) and Seaver (*Mycologia*, **6**: pl. 114).

10. *Lamprospora trachycarpa* (Curr.) Seaver var. *ferruginea* (Fckl.) comb. nov.

Syn.: *Plicaria ferruginea* Fckl. *Symb. Mycol.*, p. 326, 1869.

Apothecia large, up to 2 cm. in diameter and up to 1·3 cm. deep; external surface densely and prominently verrucose, warts large and up to 600 × 750 μ.

Apothecia up to 2 cm. in diameter and up to 1·3 cm. deep, scattered, sessile, at first globose, later expanding but remaining deep, cup-shaped, regular, fleshy, brittle; external surface brown, densely and conspicuously verrucose, warts like pyramidal tubercles, up to 600 μ long and up to 750 μ broad at the base; margin incurved, verrucose; hymenium dark brown, concave, smooth.

Asci 360–430 × 17–21 μ, cylindrical, apex obtuse in young asci but later becoming truncate in asci with mature spores, tapering below into a short stem-like base, turning blue with iodine solution.

Ascospores 12–19 μ in diameter, 8 in number, scattered when young, uniseriate when mature, light brown, smooth when young, becoming profusely verrucose at maturity, warts coarse, tubercle-like, and up to 1·5 μ long, uniguttulate, guttule filling three-fourth of the spore cavity.

Paraphyses up to 410 × 5 μ, up to 9 μ wide at the top, light brown, clavate, simple or branched near the base, enlarged at the top, septate. (Pl. VII, Fig. 1; Text-Fig. 3, A).

Collected on soil, Dhanolti, Mussoorie, September 11, 1954, **135 A**. New record in India.

This fungus differs from the typical *Lamprospora trachycarpa* (Curr.) Seaver in larger and more densely pustulate apothecia. Boudier (*Ic. Myc.*, pl. 306) illustrates the triangular or conical tufts of hyphæ forming the pustules like those in this Mussoorie collection (*n.* 135 A).

Seaver (1928) does not recognize the variety *ferruginea* and lists *Plicaria ferruginea* as a possible synonym of *Lamprospora trachycarpa*.

11. *Sepultaria arenosa* (Fckl.) Boud., *Hist. class Discom. Eu.*, 59, 1907.

Apothecia up to 1·3 cm. in diameter, medium to large-sized, gregarious, often closely crowded together, sessile, at first globose and entirely buried in the soil, later opening at the top and appearing as a
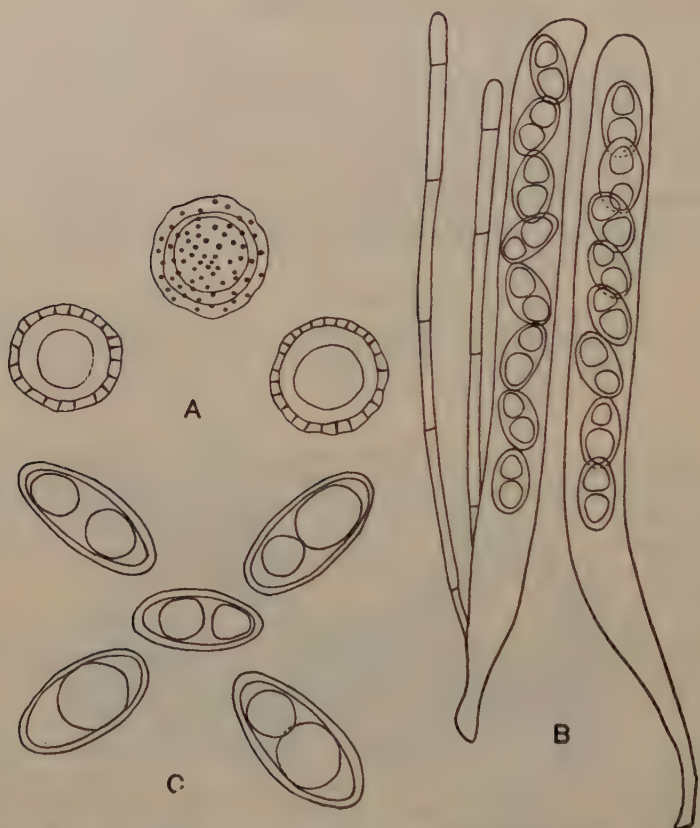
Text-Fig. 3. *Lamprospora trachycarpa* var. *ferruginea* (Fckl.) comb. nov.
A. Verrucose, uniguttulate ascospores, ×950. *Sepultaria arenosa* (Fckl.) Boud.
B. Asci and paraphyses, ×400. C. Bi-guttulate, ellipsoid ascospores, ×950.

hole on the soil surface, eventually expanding and becoming cupulate and partially superficial at the top, fleshy; external surface brown, minutely roughened and densely clothed with light brown to brown, flexuous hairs which bind the substratum together so that the whole exterior of the apothecium is encrusted with soil, exterior of the apothecium, when freed of soil by washing, looks densely woolly; hairs up to 15 μ wide, long, flexuous, brown in a mass, hyaline to subhyaline individually, straight, swollen at the top when young especially along the toothed margin, apex obtuse later on, branched, septate, slightly thick-walled, slightly broader at the base, in triangular tufts forming the dentate margin; margin usually dentate, dentations small and provided with abundant hairs, rarely splitting; hymenium deeply concave, smooth, whitish to cream-coloured.

Asci 175–200 × 12–18 μ, cylindrical, apex rounded, abruptly narrowed below into a stem-like base, do not stain with iodine solution.

Ascospores 19–25·5×8·5–12 μ, 8 in number, uniseriate, usually oblique with ends overlapping, hyaline to subhyaline, ellipsoid, ends narrowed, smooth, 1–2 guttulate.

Paraphyses up to 200×3 μ, up to 4 μ at the top, hyaline, filiform, unbranched, septate, slightly enlarged at the top (Pl. VII, Fig. 2; Text-Fig. 3, B–C).

Collected on sandy soil, Convent School, Mussoorie, August 25, 1955, **136**. New record in India.

This fungus (*n*. 136) differs from *Sepultaria arenosa* (Fuckel) Boud. in the triangular tufts of hairs forming the dentate margin. All other characters, especially 1–2 guttulate spores with narrow ends and the abruptly narrowed asci at the base, fall within the species.

12. *Humaria scutellata** (L.ex.Fr.) Fckl. *Symb. Myc.*, 321, 1869.

[= *Patella scutellata* (L.) Morgan, *J. Mycol.*, **8**: 187, 1902.]

Apothecia up to 7 mm. in diameter, gregarious, often closely crowded together, sessile, slightly cupulate when young, later on expanding and becoming scutellate, fleshy, regular; external surface brown, hairy; hairs up to 1·5 mm.×35 μ, brown, longer along the margin forming a fringe, simple, multiseptate, thick-walled, up to 8 μ thick, straight and bristle-like, swollen just above the base, apex acute; margin hairy, slightly raised; hymenium slightly concave to plane, smooth, bright red.

Asci 210–308×12·3–17·5 μ, cylindrical, apex rounded to flat, tapering below into a short stem-like base.

Ascospores 21–24·5×12·3–15 μ, 8 in number, uniseriate, parallel to oblique, ends overlapping, hyaline to subhyaline, broadly ellipsoid, inconspicuously verrucose, uniguttulate, guttule large and filling almost whole of the spore cavity.

Paraphyses up to 300×3·5 μ, up to 10·5 μ wide at the top, sub-hyaline, filiform, simple or branched, septate, considerably enlarged at the top (Text-Fig. 4, A–C).

Collected on dead wood and dead twigs, Kansro, Dehra Dun, August 31, 1952, **137**. On dead wood of *Cedrus deodara*, Dhanolti, Mussoorie, September 9, 1955, **138**.

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* Kanouse (*Mycologia*, **39**: 655, 1947) pointed out that *Humaria* is the valid generic name under the International Rules of Botanical Nomenclature for the species generally known as *Lachnea* or *Patella*. This has been accepted by Cash (*Mycologia*, **40**: 724–27, 1948). According to Kanouse the name *Humaria* must be used in the strict sense of Fuckel (*Symb. Myc.*, 1869–70) and it must not be confused with the name *Humaria* of. Saccardo (*Syll. Fung.*, **8**: 118, 1889). As the latter author used the name it is a synonym of the genus *Humarina* as pointed out by Seaver The North American Cup-Fungi (Operculates), 1928, New York].

The name *Lachnea* is invalid since it had previously been used for a genus of flowering plants as pointed out by Seaver (*Mycologia*, **40**: 498, 1948). Kanouse (*Mycologia*, **39**: 655, 1947) also pointed out that the name *Patella* that Seaver selected to avoid the use of *Lachnea* is also untenable as it is pre-Friesian.
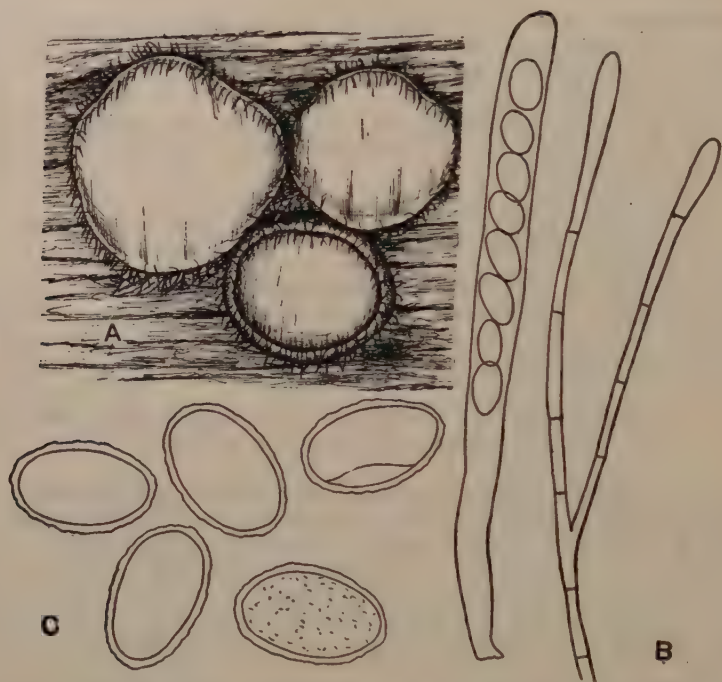
TEXT-FIG. 4. *Humaria scutellata* (L. ex. Fr.) Fckl.   A.   Hairy, scutellate apothecia, ×5.   B.   Ascus and paraphyses, ×400.   C.   Inconspicuously verrucose, uniguttulate, ellipsoid ascospores, ×950.

These collections undoubtedly belong to *Humaria scutellata* (L. ex. Fr.) Fckl. The species is characterized by scutellate apothecia with a red hymenium and brown hairs forming a fringe around the margin, broadly ellipsoid, uniguttulate spores, and paraphyses with much swollen tops.   It occurs abundantly in the Mussoorie Hills and has been collected only on dead twigs.   The same species reported from Kalika (Kumaon) by Sanwal (1953) possesses bigger apothecia.

13.   *Humaria cubensis* (Berk. & Curt.) comb. nov.

[= *Patella cubensis* (Berk. & Curr.) Seaver, *North Amer. Cup-Fungi*, p. 160, 1928.]

Syn.: *Peziza cubensis* Berk. & Curt., *J. Linn. Soc.*, **10**: 366, 1868.

Lachnea cubensis Sacc., *Syll. Fung.*, **8**: 176, 1889.

Apothecia up to 8 mm. in diameter, gregarious, external surface densely hairy, hymenium reddish orange; asci cylindric, 202–270 × 13–17·5 μ; ascospores 16·6–21 × 12·3–16·5 μ, broadly ellipsoid to subglobose, prominently verrucose, uniguttulate; paraphyses—315 × 4·4 μ, up to 7 μ wide at the top.

Apothecia up to 8 mm. in diameter, gregarious, sometimes crowded together, sessile, very slightly shallow cup-shaped due to mutual pressure or young age, later fully expanded and saucer-shaped or scutellate, fleshy-tough, regular; external surface brown, densely hairy; hairs, up to $1350 \times 35\,\mu$, deep brown, shorter on the general surface, considerably longer at the margin forming a fringe, simple, straight, bristle-like, broader below, tapering above to a sharp-pointed apex, closely septate, thick-walled, wall up to $8\,\mu$ thick; margin hairy; hymenium plane, smooth, reddish orange.

Asci 202–270×13–$17\cdot5\,\mu$, cylindrical, apex rounded, tapering below into a stem-like base, not turning blue with iodine solution.

Ascospores $16\cdot6$–$21 \times 12\cdot3$–$16\cdot5\,\mu$, 8 in number, uniseriate, usually parallel, rarely oblique, subhyaline, broadly ellipsoid, sometimes subglobose, conspicuously verrucose, warts up to $1\,\mu$ long, uniguttulate, guttule large and filling almost the whole of the spore cavity.

Paraphyses up to $315 \times 4\cdot4\,\mu$, up to $7\,\mu$ wide at the top, hyaline to subhyaline, filiform, swollen at the top, simple, rarely branched at the base, septate (Pl. VII, Fig. 3; Text-Fig. 5, A–B).

Text-Fig. 5. *Humaria cubensis* (Berk. & Curt.) comb. nov. A. Ascus and paraphyses, $\times 400$. B. Ellipsoid, uniguttulate ascospores with coarse warts, $\times 950$.

Collected on rotten wood, Kempty Fall, Mussoorie, August 15, 1952, **139**. On soil amid mosses under *Cedrus deodara* forest, Kodia, Mussoorie, September 10, 1955, **140**. New record in India.

This species, like *Humaria scutellata* (L. ex. Fr.) Fckl., is quite abundant in the Mussoorie Hills. It is closely related to *H. scutellata* from which it differs chiefly in the strongly verrucose spores. The comb. nov. proposed here is due to the fact that the generic name *Humaria* was never used previously for the species *cubensis*.

14. *Humaria hemisphærica* (Wigg. ex. Fr.) Fckl. *symb. Myc.*, 322, 1869.

[= *Patella albida* (Schaeff.) Seaver, Brenckle, *Fungi Dakot.*, 407, 1916.]

Apothecia up to 2·4 cm. in diameter, and up to 1·3 cm. deep, gregarious, or scattered, sessile, when young spherical and closed, later on opening and deep cup-shaped and appearing more or less companulate in shape, sometimes shallow cup-shaped, broader at the top and narrower at the base, fleshy-tough; external surface dark brown, densely hairy, rough; hairs up to $1385 \times 20 \mu$, rarely up to 30μ wide, long, brown to deep brown, rigid and bristle-like, broader at the base, tapering above to an acute apex, forming a dense fringe around the margin, unbranched, thick-walled, wall up to 3μ thick, multiseptate, septa at short intervals; margin hairy, slightly incurved, much darker than the external surface, wavy; hymenium deep concave, smooth, whitish or pallid or dirty milk white.

Asci $185-230 \times 10·5-15·3 \mu$, cylindrical, apex rounded, abruptly narrowed below into a short stem-like base, slightly bulging out against the ascospores, do not stain with iodine solution.

Ascospores $16-26·6 \times 10·5-13 \mu$, 8 in number, uniseriate, usually oblique, ends overlapping, hyaline to subhyaline, ellipsoid, distinctly verrucose, warts minute, papilla-like, blunt and up to $0·8 \mu$ long, 1–2 guttulate.

Paraphyses up to $265 \times 2 \mu$, up to $6·7 \mu$ wide at the top, subhyaline, slender, unbranched, septate, prominently enlarged at the top (Text-Fig. 6, A–C).

Collected on soil under *Cedrus* forest, Camel's Back Road, Mussoorie, August 15, 1952, **141**. On soil and on dead twigs under *Cedrus* forest, Dhanolti, Mussoorie, August 26, 1955, **142**. New record in India.

This fungus is very common in the Mussoorie Hills and is easily recognized by large apothecia with whitish hymenium and minutely verrucose, 1–2 guttulate ascospores. The hairs in the Mussoorie collections are much longer for the species.
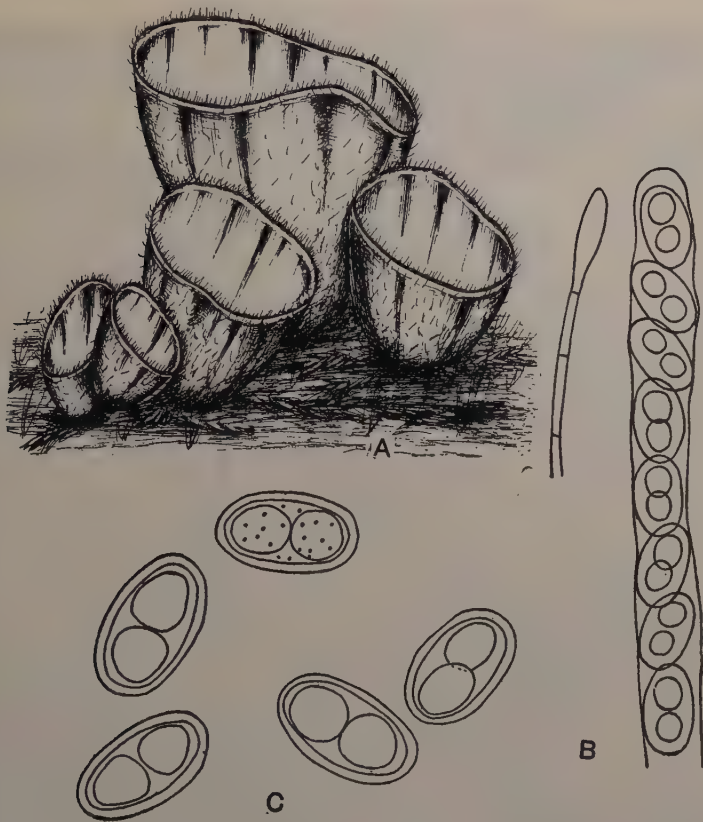
TEXT-FIG. 6. *Humaria hemisphærica* (Wigg. ex. Fr.) Fckl. A. Hairy, companulate apothecia, ×5. B. Ascus wall bulging out against the spores, ×500. C. Minutely verrucose, 2-guttulate ascospores, ×950.

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Explanation of Plate VII

Fig. 1.   *Lamprospora trachycarpa* var. *ferruginea* (Fckl.) comb. nov. showing very
          large and densely pustulate apothecia.

Fig. 2.   *Sepultaria arenosa* (Fckl.) Boud. showing apothecia with dentate margin.

Fig. 3.   *Humaria cubensis* (Berk. & Curt.) comb. nov. showing scutellate apothecia
          with dense hairs forming a fringe along the margin.

K. S. Thind and J. S. Sethi
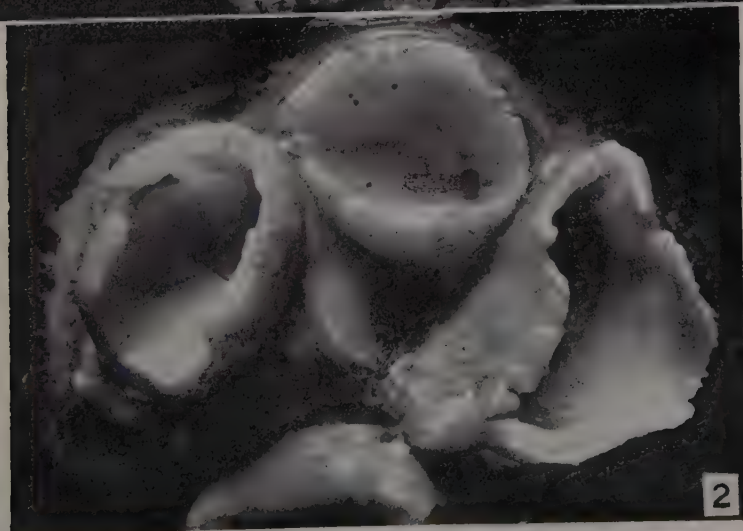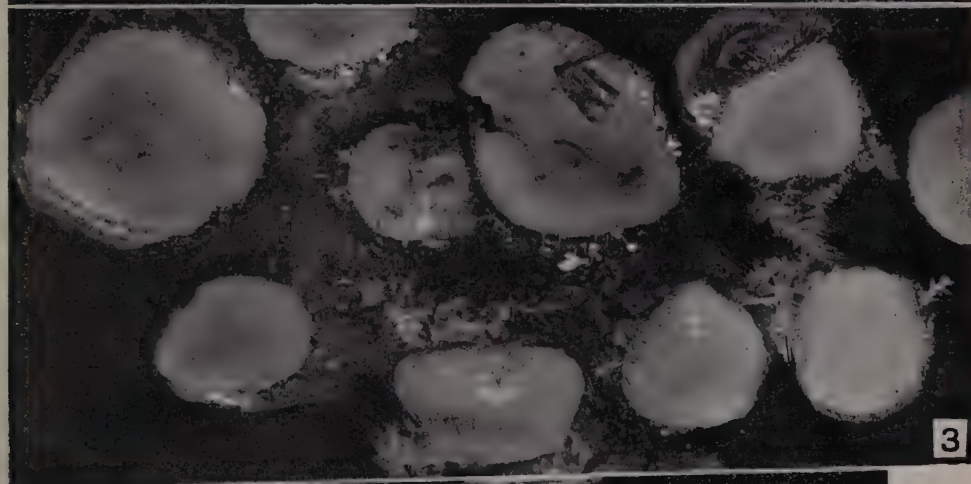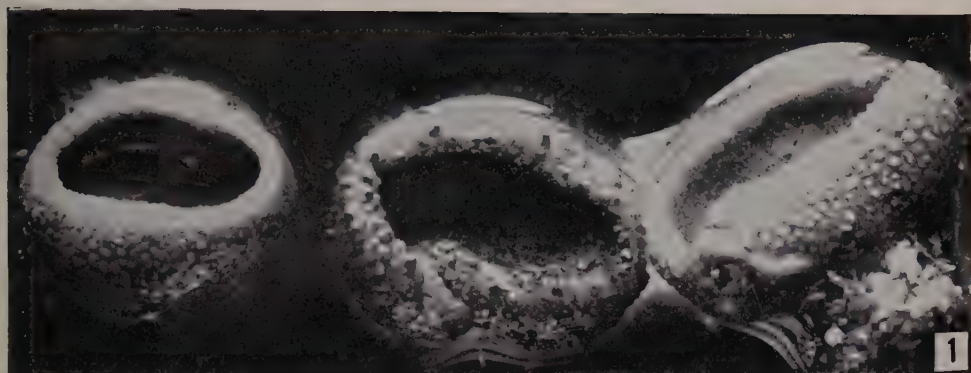
EMBRYOLOGICAL STUDIES IN *DÆMIA EXTENSA* BR.

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Introduction

The family Asclepiadaceæ has been included by Engler (1897) in the sub-order Gentianineæ along with Apocynaceæ and four other families. Wettstein (1935) and Rendle (1938) include Loganiaceæ, Gentianaceæ, Apocynaceæ and Asclepiadaceæ in the order Contortæ. Loganiaceæ and Gentianaceæ stand somewhat apart from the Asclepiadaceæ and Apocynaceæ which are closely allied. Hutchinson (1926), however, includes the families Asclepiadaceæ and Apocynaceæ into a separate order Apocynales and places Loganiaceæ and Gentianaceæ respectively under the orders Loganiales and Gentianales.

The family Asclepiadaceæ is chiefly pantropical in distribution. A few genera occur in the temperate regions of the Northern and Southern hemispheres. Willis (1931) recognised 320 genera, while Rendle (1938) 280. The number of species recorded is about 1,800.

The contribution to the embryology on the Asclepiadaceæ is comparatively meagre. The earlier literature on embryology of this family has been reviewed by Finn (1925), Sabet (1931), Schnarf (1931) and later work by Patwardhan (1953), Rao and Rao (1954), and as such, it needs no repetition here.

The genus *Dæmia* has been placed under the tribe Cynancheæ of the sub-order Euasclepiadaceæ by Hooker (1885) and under the sub-family Cynanchoideæ by Schumann (1895), Wettstein (1935) and Rendle (1938).

Dæmia extensa is one of the six species belonging to the genus *Dæmia*. It is a twining, pubescent undershrub with milky latex, characterized by opposite cordate leaves and axillary corymbiform cymes.

Dæmia extensa is distributed throughout India. In Bengal, it occurs in all the districts. It is found in several localities of Calcutta and suburbs, specially in the saline areas.

Material and Methods

Material for study was collected from Ultadanga area (Calcutta) in the months of August and September, and was fixed in formalin-acetic-alcohol. Excepting the very young buds, the outer floral whorls were removed and the ovaries and fruits of different sizes were cut into

small pieces before fixation. For dehydration and clearing, ethyl alcohol and chloroform grades were used. Sections were cut from 5–12 μ thick, depending on the stage required for study, and were stained in Heidenhain's iron alum-hæmatoxylin. Orange G was used as a counterstain for certain preparations.

For the study of meiosis, flower buds of suitable size were treated with Carnoy's fluid, washed thoroughly in distilled water and fixed in Nawaschin's fluid in the field between 10·30–11·30 A.M., which was found to be the normal time of division of the pollen mother cells. They were dehydrated through tertiary-butyl-alcohol series. Sections were cut 7–8 μ thick and were stained in Crystal violet-iodine.

MICROSPOROGENESIS

A transection of the young anther shows that the archesporium is hypodermal in origin and differentiates at two places. It consists of a row of cells in the form of a plate which is 6–8 cells wide (Fig. 1) and 8–10 cells deep (Fig. 2). The archesporial cells divide periclinally to form a primary parietal layer and the primary sporogenous layer. The parietal layer thus produced undergoes repeated periclinal divisions and produces 2–3 layers of cells of which the innermost layer functions as the tapetum (Fig. 4). The tapetum is of the secretory type. It is uniseriate and consists of closely arranged uninucleate cells (Figs. 8, 10). The cells are full of dense cytoplasm and provide food materials to the developing microspores. Rao and Rao (1954) reported fibrous thickenings in the endothecial layers in *Caralluma attenuata*, but in the present material, no such thickening of the hypodermal layer has been observed.

The primary sporogenous cells function directly as the microspore mother cells (Fig. 3). In an anther lobe microspore mother cells are arranged in 6–8 rows, each row consisting of 5–6 cells. Thus, in transverse section of the anther, 5–6 sickle-shaped microspore mother cells are observed in a row as illustrated diagrammatically in Fig. 5. The pollen mother cells of *Dæmia* are much elongated in the early stages of meiosis (Fig. 7).

The meiotic division is synchronous in an anther lobe and appears to proceed normally. In polar view of metaphase I, eleven bivalents have been counted (Fig. 6). The spindles of first and second divisions are always oriented parallel to the long axis of the microspore mother cells (Figs. 7, 8). Immediately after the first division, a cell wall is laid down at right angles to the long axis of the spore mother cell and produces a dyad. A linear tetrad of microspores is formed by successive wall formation in each of the two daughter dyads (Fig. 9) as has been previously observed by Gager (1902), Rao and Rao (1954) in other genera of the sub-family Cynanchoideæ. Initially, the microspores are quadrangular in shape and are arranged in a regular linear series but later their shape and position are changed due to rounding up of the pollinium. The pollen grains never separate from one another but
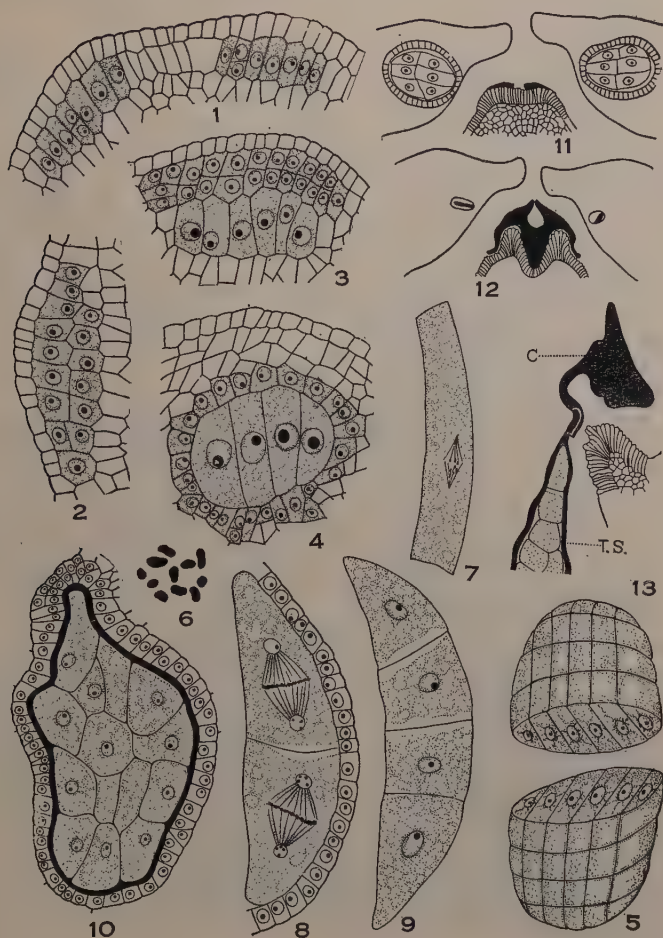
TEXT-FIGS. 1–13. *Dæmia extensa*. Figs. 1 and 2. T.s. and L.s. of anther primordia respectively, showing archesporium, ×137. Fig. 3. T.s. of young anther lobe showing the origin of sporogenous layer, ×137. Fig. 4. T.s. of young anther lobe showing sporogenous cells, wall layers and the differentiated tapetum, ×137. Fig. 5. Diagrammatic representation of the arrangement of microspore mother cells in a pollinium. Fig. 6. Metaphase I showing 11 bivalents, ×1,7.0. Figs. 7–9. Stages in the formation of microspore tetrad, ×274. Fig. 10. T.s. of anther lobe with pollinium, surrounded by uninucleate tapetal cells; note the thick tapetal secretion enclosing the pollen mass, ×178. Fig. 11. T.s. of flower bud showing secretion of corpusculum by the glandular cells of the stigmatic ridge at dyad stage of the microspore mother cells, ×65. Fig. 12. T.s. of flower bud showing a fully formed corpusculum with its lateral processes, ×65. Fig. 13. L.s. of flower bud showing formation of the retinaculum by union of the extended process of both the tapetal secretion and the corpusculum, ×80. Corpusculum with lateral process·C; Tapetal secretion—T.S.

7

remain together to form a pollinium, a characteristic feature of the sub-family Cynanchoideæ (Fig. 10).

A study of the development of the pollinium with its corpusculum (gland) and retinaculum (translator arm) has revealed some interesting features. A transverse section of the flower bud at the level of stigma shows that the stigma head which is round in the initial stages becomes pentangular later and is surrounded by the five bilocular anther lobes, which, however, are not adpressed to it (Fig. 14). The epidermis of the stigmatic head is composed of secretory cells which have dense cyto-plasm and elongated nuclei (Fig. 15). Soon the glandular cells situated at the lateral sides of the stigmatic ridge elongate rapidly and produce a depression at the summit of the ridge (Figs. 11, 12). The secretion of the glandular cells adjacent to both sides of the depression collects into it from the two sides. The corpusculum thus in its early stage of development is distinctly 2-parted (Fig. 11). It should be pointed out that the corpusculum begins to be secreted by the cells of the stigmatic ridge at the stage when the microspores are in the dyad or tetrad stage. The tapetal cells surrounding the microspores, however, show no sign of secretion at this stage. The secreted substance solidifies and appears dark at the central region. Lateral processes develop from this on both sides (Fig. 12). These processes of the corpusculum which form the part of the retinacula, are also the secretory product of the cells on the lateral sides of the stigmatic ridge.

Later, the pollen mass becomes encased by the tapetal secretion (Fig. 10) which finally extends outside in a filiform manner through the stomium formed by the disorganization of the cells of the anther wall. The secreted liquid solidifies about the pollen as well as outisde the anthers. The terminal end of the filiform process attaches itself to the lateral process of the corpusculum and forms the translator (Fig. 13). Thus, a pair of pollinia from two contiguous anther halves is joined on both sides with the lateral processes of the corpusculum by lateral exten-sions of the tapetal secretion, enveloping the pollen mass (Figs. 11–13). The retinaculum thus is derived from lateral extensions of both the tape-tal secretion and the corpusculum (Fig. 13) in the genus *Dæmia*, where pollinia are pendent.

The tapetum is ultimately consumed in the process of secretion.

MALE GAMETOPHYTE

The young microspores show the presence of dense cytoplasm with a centrally placed nucleus. Later, the microspores increase in volume. The position of the nucleus becomes eccentric and it lies adjacent to the wall (Fig. 16). The nucleus then divides to produce the vegetative and generative nuclei (Figs. 17, 19). Eleven chromosomes have been counted at this stage (Fig. 18). No true cell plate is formed but the cells are separated by a clear concave space. The generative cell is lenticular in outline and smaller in size than the vegetative cell (Fig. 19). Its cytoplasm is denser and stains deeply in comparison to that of the vegetative cell which is much vacuolated. Later, the generative cell is
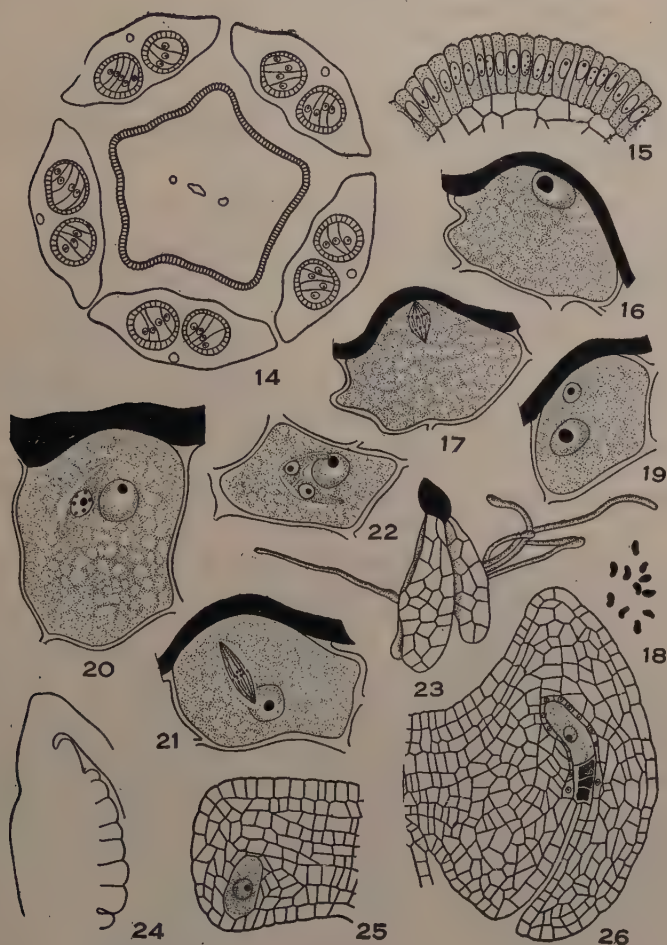
Text-Figs. 14–26. *Dæmia extensa.* Fig. 14. T.s. of flower bud at the level of the stigmatic head, ×50. Fig. 15. Glandular cells at the ridge of the stigma, before secretion of the corpusculum, ×445. Figs. 16–22. Development of male gametophyte; explanation in the text, ×445. Fig. 18. Eleven chromosomes from the microspore, ×1,750. Fig. 23. Germination of pollinium, ×31. Figs. 24–26. L.s. of the pistils. Fig. 24. Corrugated placental surface showing ovule primordia, ×40. Fig. 25. Ovule primordium showing hypodermal origin of the megaspore mother cell, ×310. Fig. 26. A full grown ovule with scanty nucellus, functional and degenerating megaspores and massive integuments, ×298.

surrounded by a cytoplasmic sheath and its appearance is somewhat like that of a spindle (Fig. 20). The generative cell next divides while it is in the pollen grain (Fig. 21). Cytokinesis resulting in a bipartitioning of the cell takes place by laying down of a cell plate as in *Asclepias* (Finn, 1925) (Fig. 22). The mature pollen grains are

trinucleate. The male gamete has one end truncated and the other drawn out in an attenuated process, thus appearing triangular in form (Fig. 22).

The pollen grains germinate in the pollinium itself under moist condition and the pollen tubes come out after piercing through the outer membrane of the pollinium (Fig. 23).

THE OVULE AND THE INTEGUMENT

The ovules are arranged on two massive marginal placentas. In the early stages of development of the ovule, the smooth surface of the placental tissue becomes corrugated (Fig. 24). The ridges of the corrugation enlarge and later on become hemispherical to produce the nucellus of the ovules (Fig. 25). The ovules are unitegmic, tenuinucellate and possess short funicle. The integumental primordium arises near the top of the nucellus. It grows rapidly and covers up the nucellus completely during the dyad to tetrad stage of the embryo sac (Fig. 26).

MEGASPOROGENESIS AND THE DEVELOPMENT OF THE FEMALE GAMETOPHYTE

The archesporial cell differentiates before the integumental primordium. It is hypodermal in origin and directly functions as the megaspore mother cell (Fig. 25). It increases in size and becomes somewhat elongated (Fig. 27). The first division of the megaspore mother cell is reductional and results in the formation of a dyad (Figs. 28, 29). Both the cells of the dyad generally undergo division simultaneously (Fig. 30); sometimes, however, the basal cell divides earlier than the terminal one. As a result of the division, a linear tetrad of megaspores is formed (Fig. 31), of which the three micropylar megaspores degenerate and the chalazal one elongates and becomes functional (Fig. 33). Usually the micropylar megaspore first degenerates, followed by the others, but in some cases the second megaspore from the chalazal end has been found to show signs of degeneration even when the apical (micropylar) cell of the dyad is in a dividing condition (Fig. 32). The degenerated megaspores can be made out as dark masses capping the functional megaspore (Fig. 33). The chalazal megaspore by three successive divisions produces an 8-nucleate embryo sac in the normal way (Figs. 34–36).

The mature embryo sac is curved and elongated. It is more or less broad at the middle. The synergids are hooked and pear-shaped bodies, each with a terminal beak-like extension and a large vacuole at the basal end (Fig. 38). The egg cell is comparatively large and projects below the synergids. The two polar nuclei fuse before fertilization (Fig. 37). The antipodals are elongated and with vacuoles (Fig. 39). They are ephemeral. Starch grains have been found to be present in the mature embryo sac (Fig. 37). The nucellus consists of a single layer of cells which, however, is crushed during the development of the embryo sac. The scanty nucellar tissue begins to degenerate at about the binucleate stage of the embryo sac. After the degeneration of the
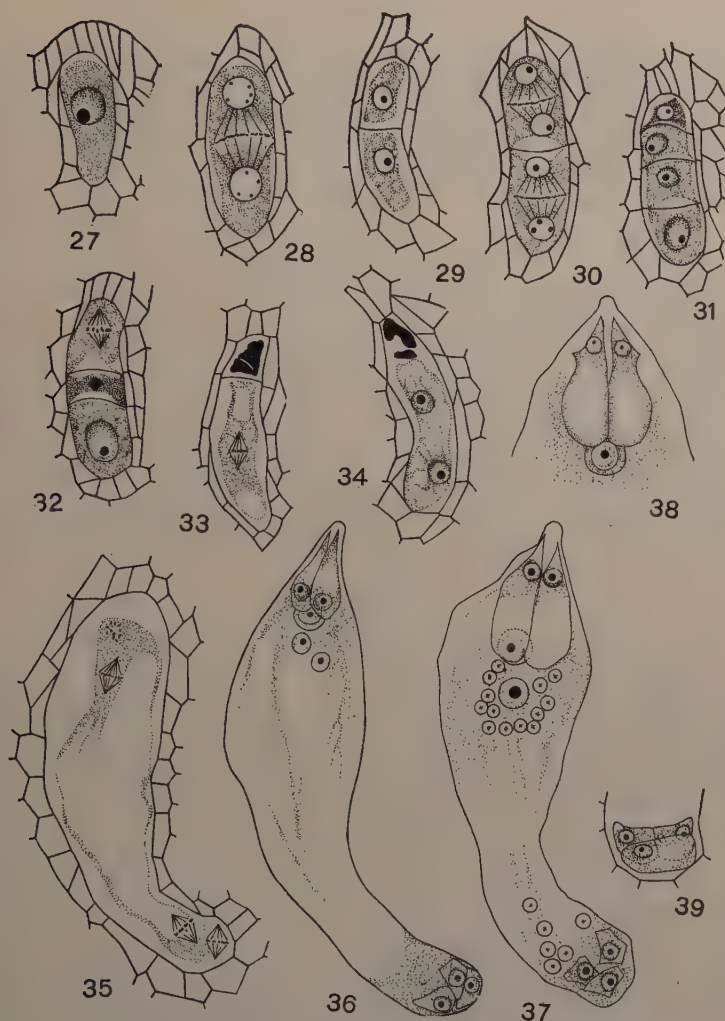
TEXT-FIGS. 27–39. Different stages in the development cf female gametophyte of *Dæmia extensa.* Figs. 27–31. Stages in the development of linear tetrad of megaspores, × 500. Fig. 32. Second megaspore from the chalazal end showing sign of degeneration even when the apical (micropylar) cell is in dividing condition, × 500. Figs. 33–35. Stages in the development of 8-nucleate embryo sac, × 500. Fig. 36. Young embryo sac before fusion of the polar nuclei, × 500. Fig. 37. Mature embryo-sac with starch grains, × 500. Fig. 38. Egg apparatus showing hooked nature of the synergids and the position of the egg cell, × 500. Fig. 39. Anti-podals, × 500.

nucellar layer, the mature embryo sac is encased by the innermost cell layer of the integument.

Fertilization

As in most angiosperms, fertilization is porogamous. Pollen tubes have been seen to enter the embryo sac by way of the micropyle and discharge their contents therein. One of the male gametes fuses with the egg and the other with the polar fusion nucleus almost at the same time. Triple fusion is evident from the triploid chromosome complement found in the cells of the endosperm (Fig. 55).

Endosperm

The endosperm in *Dæmia extensa* is free nuclear in its early stages of development (Figs. 53, 54). The primary endosperm nucleus divides freely and at about 16–32 nucleate stage, walls are laid down. As usual, the endosperm nucleus divides earlier than the zygote. Even when the endosperm tissue almost fills up the embryo sac cavity, the fertilized egg shows no sign of segmentation. Later on, by successive division, the endosperm forms an extensive tissue and completely fills up the embryo sac cavity. The mature endosperm cells are uninucleate and irregular in outline (Fig. 56). The nucleus sometimes shows the presence of 2–3 nucleoli. The presence of endosperm haustoria has not been observed.

Embryo

The detailed embryogeny of *Dæmia extensa* agrees more or less with that of *Cryptostegia grandiflora* (Rao and Rao, 1954) and *Asclepias curassavica* (Crété, 1950). The egg rests for sometime after fertilization (Fig. 40). During this period the endosperm tissue almost fills up the embryo sac cavity. At about 64-celled condition of the endosperm, the fertilized egg divides by a transverse wall into the terminal cell ca and the basal cell cb (Figs. 41, 42). The basal cell cb again divides transversely into cells m and ci (Fig. 43). Then ca after transverse division forms a linear filamentous proembryo composed of four cells which are designated as l, l', m, ci (Fig. 44). Next l' undergoes transverse division to form ph and h (Figs. 45, 46). At this stage generally l divides by a longitudinal wall (Fig. 46). The cell m undergoes further transverse division to produce d and f. The cell d, a descendent of m, becomes a hypophysis cell and the cell f contributes to the suspensor. The cell ci by further transverse division produces a much elongated suspensor, whose cells are designated as f, n, o, p, etc. (Fig. 47). Later l by another longitudinal wall at right angles to the previous one, forms a quadrant (Fig. 48). The cells ph and h by vertical divisions produce two tiers of cells (Fig. 49). The quadrant by diagonal and later by periclinal division of its cells demarcates the dermatogen on the outside (Figs. 50, 51). The inner cells by further vertical divisions produce periblem and plerome initials (Fig. 50). The tier l is thus destined to produce the cotyledons and shoot tip. Cells ph, h, and d by successive longitudinal and transverse divisions ultimately produce hypocotyl, central cylinder of root, root-tip and root-cap respectively. In early stages of development the suspensor is uniseriate but later, it becomes biseriate (Fig. 52).
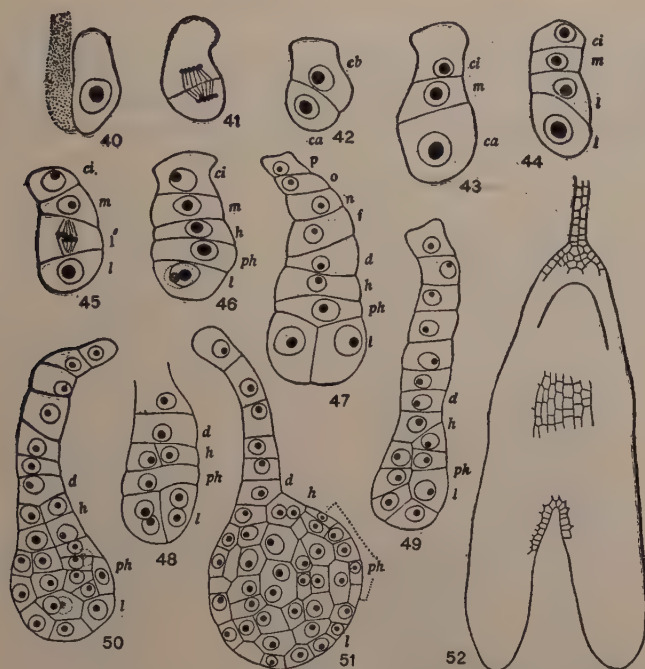
TEXT-FIGS. 40–52. Various stages in the development of embryo in *Dæmia extensa*; explanation in the text. Fig. 40. Zygote with part of pollen tube, ×700. Figs. 41–43, 45–48, ×700. Fig. 44, ×866. Figs. 49–51, ×433. Fig. 52, ×106.

The terminal cell of the two-celled proembryo divides by a transverse wall. The suspensor is derived from the basal cell and is composed of two or more cells. The embryo proper is terminal and the linear proembryo is a tetrad. A hypophysis initial is also present. Thus according to Johansen's (1950) classification, the embryo in *Dæmia extensa* may be regarded as the Linum variation of the Solanad type.

The mature embryo shows two large cotyledons with a broad cylindrical hypocotyledonary region (Fig. 52). Four to five layers of endosperm cells have been seen to surround the mature embryo. The destination of the different tiers is represented below:—
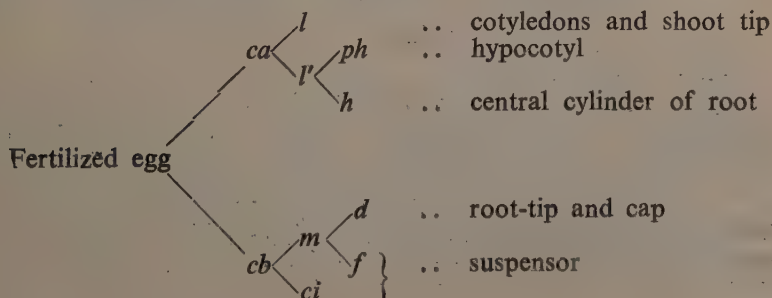
SEED AND SEED HAIRS

Mature seeds of *Dæmia extensa* are rugose, ovate, bilaterally flattened and comose (Fig. 61). The development of coma, which is an adaptation for the wind dispersal of the seeds, has been studied. At about the 2-nucleate stage of the endosperm, the epidermal cells of the
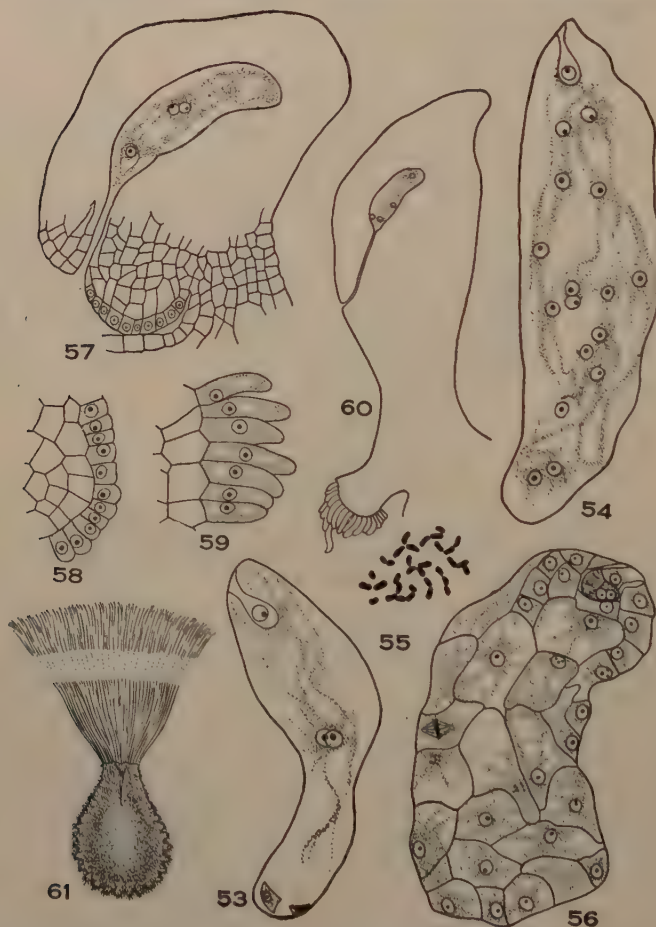
TEXT-FIGS. 53–61. *Dæmia extensa*. Figs. 53–56. Stages in the endosperm development. Fig. 53. First division of the endosperm nucleus, ×335. Fig. 54. Sixteen nucleate condition of the endosperm, ×335. Fig. 55. Triploid chromosome complement ($3 n = 33$) in an endosperm cell; chromosomes occur mostly in linear groups of three, ×1,750. Fig. 56. Embryo sac with young embryo and endosperm which has become cellular; note division of some of the endosperm nuclei, ×274. Figs. 57–61. Various stages in the coma development. Fig. 57. Ovule, just after the commencement of coma formation, ×235. Figs. 58, 59. Stages in the development of coma, ×342. Fig. 60. Ovule with fully developed coma at the terminal end, ×80. Fig. 61. Mature seed with coma, ×5.

integumentary tissue adjoining the funicle and forming the inner lip of the micropyle become active and constitute the coma producing area (Fig. 57). The cells of this region next increase in size and gradually differentiate as hairs (Figs. 58–60). It may be noted, however, that all the cells of the area undergo further development, but some of them remain inactive. As observed earlier by Frye (1902) and Pearson (1948), the cells producing the coma do not show any activity till the endosperm reaches at least the 8-nucleate stage. The epidermal cells forming the outer lip of the micropyle, however, do not take part in the development of the coma (Fig. 57). In the development of the coma, the nucleus at first remains at the base of the cell. Along with the gradual elongation of the cells, the cytoplasm becomes highly vacuolated. Ultimately, only a narrow strip of cytoplasm lines the inner wall of the cells. The nucleus generally migrates to the middle of the cell, but the migration is not uniform in all the hairs. At maturity the hairs become free from each other and remain attached at the narrow end of the seeds in a tuft (Fig. 61).

The maximum length and breadth attained by the mature hairs are 2·5 to 3 cm. and 24·8 to 31 μ respectively. The mature hair does not show any twist as is commonly present in cotton. The walls of the fibres are cellulose in nature and shows secondary deposition of cellulose and other materials. The average breadth of the wall of mature fibres is 2·3 to 3·1 μ.

DISCUSSION

Rendle (1938) separates the family Asclepiadaceæ from the family Apocynaceæ on the basis of the transference of the pollen by means of specialized translators or directly from the anthers.

The embryological studies so far made on the two closely related families indicate that the anther tapetum is of the glandular type in both but quadripartition of the microspore mother cells takes place by cell plates in Asclepiadaceæ and by furrowing in Apocynaceæ. Meyer (1938), however, records successive type of pollen formation in *Rauwolfia canescens*. In Asclepiadaceæ, pollen grains are united into pollinia in the sub-family Cynanchoideæ and into tetrads in the sub-family Periplocoideæ, while in Apocynaceæ pollen grains are never united into pollinia, but tetrads of the type as seen in Periplocoideæ occur in several genera (Erdtman, 1943).

Regarding the placenta, form of ovule, the origin and extent of the integumentary tissue of the ovule, both the families show similar organisation. Slight difference, however, appears to be present in the development of the integument in the Asclepiadaceæ, where there is more rapid growth on one side. Further, there is no recognisable difference so far as megasporogenesis, development and organisation of the mature embryo sac and fertilization are concerned.

There is no variation in the development of endosperm which is of the nuclear type in both. The development of embryo in Apocynaceæ is characterized by the Sedum variation of Caryophyllad type,

while in Asclepiadaceæ it is Linum variation of Solanad type (Johansen, 1950).

The embryological characters, which are considered to be of taxonomic importance, of the above two closely related families reveal some difference by which they can be separated from each other. But considering the similarities existing between them, they may easily be included under a single order Apocynales, as has been done by Hutchinson (1926).

Meiosis presents no irregularities. The haploid chromosome number, as determined from the first and the second divisions, is definitely eleven. Nirula (1945 a), however, states that " the heterotypic division was regular and reductional, the haploid number of chromosomes being twelve ". In the light of the present investigation, Nirula's (1945 a) determination is open to question.

The translator mechanism is peculiar among the subfamily Cynanchoideæ of the family Asclepiadaceæ. Its presence distinguishes the subfamily Cynanchoideæ from the subfamily Periplocoideæ (Wettstein, 1935; Rendle, 1938). Woodson (1941) studying some American Asclepiadaceæ has noted that " in the early development of pollinia, the tapetal liquid .... seeps through small pores of the neighbouring anthers to gather in the commissural grooves of the two organs. This liquid later solidifies outside the anther as well as about the pollen " to form the retinaculum (translator arm) and the corpusculum (gland). Rao and Rao (1954) state that in *Caralluma attenuata*, the corpusculum is derived by the periclinal division of the epidermal cells of the stigmatic ridges and by subsequent disintegration and hardening of the outer layer. The tapetal secretion around the pollinium extends in a filiform manner through the stomium and joins the corpusculum forming the retinaculum.

The present study reveals that the corpusculum is formed by the secretion of the glandular cells at the stigmatic ridge. As stated before it is secreted before the tapetal secretion commences. The secretory substance of the tapetal cells encloses the pollen mass, extends through the stomial opening and joins the lateral processes of the corpusculum. It should be mentioned here that no periclinal division of the epidermal cells in the ridges of stigma has been observed in the present study. The cellular nature of the corpusculum and the retinaculum has not been observed even in the early stages of development. The corpusculum is the secretory product of the glandular cells of the stigmatic ridge and not the product of the tapetal secretion alone, as has been suggested by Woodson (1941) or the disintegrated product of the outer layer of the cells of the stigmatic ridge as mentioned by Rao and Rao (1954).

The present study clearly indicates that in *Dæmia*, where pollinia are pendent, the corpusculum and the retinaculum are of different origin, the latter being derived partly from the extended processes of the tapetal secretion and the corpusculum.

Nirula (1945*b*) seems to be the first to have worked out the development of the female gametophyte in *Dæmia extensa*. He observed T-shaped, inverted T-shaped, and L-shaped tetrads and noted the absence of wall formation between the respective megaspores in an L-shaped tetrad. He further states that " in all the cases of different types of tetrads, it is the outermost megaspore that functions, while the other three begin to degenerate. This is an interesting feature, for in a large majority of Angiosperms, it is the innermost megaspore that grows further, while the outer three degenerate". Patwardhan (1953), however, does not confirm Nirula's (1945 *b*) observations. She has noted that in *Dæmia extensa* the chalazal megaspore alone develops into the embryo sac. The present study corroborates Patwardhan's (1953) observations.

The presence of variations in the arrangement of megaspores or the absence of wall formation between the megaspores as stated by Nirula (1945 *b*) has not been observed in the course of this investigation. The present study shows presence of linear tetrad of megaspores only.

In *Dæmia extensa* a short free nuclear stage precedes the cellular development of the endosperm. Holmgren (1919) and Schnarf (1919) in their studies on both nuclear and cellular types of endosperm formation in the same species have also recorded the above-mentioned condition in apogamous *Eupatorium glandulosum* and *Hieracium aurantiacum*. They are of opinion that " if the polar nuclei fuse, the endosperm formation is cellular, if the fusion fails, the polar nuclei divide independently and a short nucleate stage precedes the cellular development of endosperms " (quoted from Sabet, 1931). But the present study on *Dæmia extensa* shows that the last mentioned condition occurs in the development of endosperm even when the polar nuclei fuse. So it is not possible to explain the present condition on the basis of their observations.

The question, what type of endosperm, nuclear or cellular, is primitive, is an open one (Maheshwari, 1950). According to Dahlgren (1923) " the nucleate type is the more primitive " and according to Svensson (1925) " between the normal nuclear and the *ab initio* cellular endosperm, nearly all imaginable intermediate types are found " (quoted from Sabet, 1931). In consideration of the above views, therefore, in the present species, the precedence of the short nuclear type over the cellular development of the endosperm, may be regarded as the intermediate derived type.

Regarding the wall formation of the endosperm cells, Sabet (1931) working on *Calotropis procera* and Moore (1946) on *Asclepias syriaca* found that it begins at the 16-nucleate stage. Frye (1902), however, observed wall formation to begin as early as the 8-nucleate stage in the species studied by him. Rao and Rao (1954) in *Caralluma attenuata* and *Cryptostegia grandiflora* likewise found that it commences at 16-32-nucleate stage. The beginning of the cellular condition appears to be initiated in the present material at about 16-32-nucleate stage and not in the 8-nucleate stage as was previously observed by Nirula (1945 *b*).

In *Dæmia extensa*, the coma producing area is confined to the epidermal cells of the integumentary tissue adjoining the funicle as observed by Pearson (1948) in *Asclepias syriaca*.

Rao and Rao (1954), however, state that the coma producing hairs which develop from the epidermal cells around the micropyle and funicle gradually become papillate and free from one another by schizogenous splitting of the middle lamellæ. As has been pointed out elsewhere, the hairs are separate from the initial stages of their development and in no stage they have been found to be united together, so that the question of a schizogenous splitting of the middle lamella of the cells does not arise at all. Further, the figures given by Rao and Rao (1954) do not appear to corroborate their statement.

SUMMARY

The paper gives an account of the embryological studies in *Dæmia extensa*.

Meiosis is regular. Eleven bivalents have been noted at metaphase I.

Pollen formation is of the successive type and results in a linear tetrad of microspores. The pollen grains are trinucleate. The male gametes have one end truncate and the other attenuated and drawn out. The tapetum is of the secretory type and is composed of a single layer of uninucleate cells.

In the development of the pollinium, the glandular cells of the stigmatic ridge produce a secretion, which becomes cartilagenous and form the bi-hooked corpusculum (gland) at the centre. Lateral prolongations develop from this on both sides. The tapetal secretion, which envelops the pollen grains, appears to be of a similar nature to that given out by the glandular stigmatic cells. The tapetal secretion enveloping the pollen mass extends outward at the stomial region and unites with the lateral processes of the corpusculum to form the retinaculum (arm).

The ovules are anatropous, tenuinucellate and unitegmic. The archesporial cell is hypodermal in origin and directly gives rise to the megaspore mother cell. A linear tetrad of megaspores is formed of which the chalazal functions to give rise to an 8-nucleate embryo sac. The embryo sac is of the "*Polygonum type*" and shows the presence of starch grains in the mature condition. Fertilization is porogamous. Syngamy and triple fusion have been observed and the triploid nature of the endosperm cells has been determined. The endosperm passes through an early free nuclear stage before becoming cellular. Embryo development corresponds to the Linum variation of the Solanad type.

Seeds are bilaterally flattened and comose. Coma develops from the epidermal cells of the integumentary tissue adjoining the funicle which forms the inner lip of the micropyle.

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SOME ASPECTS OF THE EMBRYOLOGY OF *DIANELLA NEMOROSA* LAMK.

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THE genus *Dianella* belonging to the subtribe Dianellinæ of the Liliaceæ is embryologically little known. In a recent review "Cytology and embryology in the delimitation of genera", Cave (1953) has mentioned some of the main embryological features of the genus *Dianella*. The present paper deals with some aspects of embryology of *Dianella nemorosa*.

The material of *Dianella nemorosa* for the present study was collected in Peradeniya Gardens, Ceylon, and was generously passed on to me by M. R. Anandaramaiah, Curator, Botanical Gardens, Bangalore, to whom I tender my sincere thanks. Some of the embryological features available from the limited amount of material I had, have been represented in this paper.

Dianella nemorosa is a small stoloniferous plant with rigid distichous linear leaves. The paniculate inflorescences bear hermaphrodite trimerous flowers. The fruit is a berry enclosing compressed seeds.

OBSERVATIONS

Microsporangium and male gametophyte.—A fairly young anther in a transverse section shows a group of microspore mother cells bounded by the wall (Fig. 1). The innermost layer of the microsporangium wall differentiates into the tapetum and its cells become binucleate and densely filled with cytoplasm during subsequent stages (Fig. 2). The middle layer external to the tapetum gets disorganized (Figs. 2, 3). The epidermis and the endothecium remain for a long time. The anthers dehisce by terminal slits.

The pollen mother cells undergo reduction division to form tetrahedral tetrads of microspores which later differentiate into pollen grains (Figs. 4–7). The pollen grains are two-celled at the shedding stage (Fig. 8). They are slightly triangular in the polar view and reniform in side view (Figs. 9, 10). At the distal end of each grain there is a trichotomously branched sulcus (Fig. 9).

Ovary and ovules.—The tricarpellary ovary is trilocular enclosing a few ovules and terminates in a simple style. The septal nectaries, which are fairly common in the Asphodeleæ and Anthericinæ, are absent. The epitropous ovules are bitegmic and crassinucellate (Figs. 11–14). Periclinal divisions are invariably noticed in the nucellar epidermis at the micropylar end (Figs. 16–21).
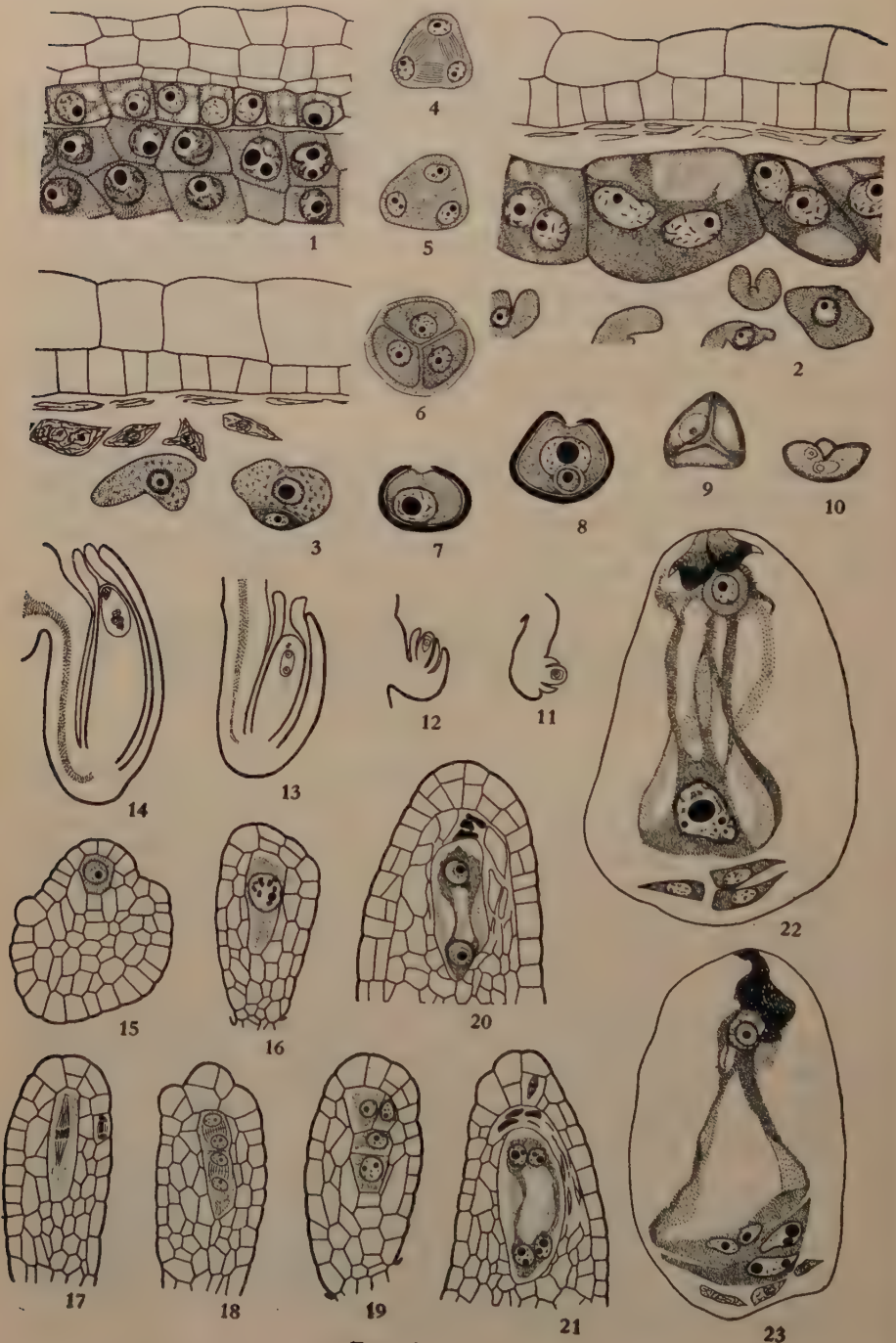
Figs. 1—23.

TEXT-FIGS. 1–23. Fig. 1. Portion of anther showing pollen mother cells and the wall. Fig. 2. Same at a later stage showing crushed middle layer, binucleate tapetal cells and pollen grains. Fig. 3. A still later stage of the same with pollen at the shedding stage. Figs. 4–6. Stages in the development of microspore tetrad. Fig. 7. A pollen grain with thick exine and a thin intine. Fig. 8. Two-celled pollen grain. Fig. 9. Polar view of pollen grain showing the sulca. Fig. 10. Side-view of the same. Figs. 1–10, ×647. Figs. 11–14. Stages in the development of the ovule, ×34. Fig. 15. Nucellar primordium with the archesporial cell, ×323. Figs. 16–17. Division of megaspore mother cell. Note divisions in nucellar epidermis, ×323. Fig. 18. Simultaneous division of dyad cells to organise a linear tetrad of megaspores, ×323. Fig. 19. T-shaped tetrad of megaspores, ×323. Fig. 20. 2-nucleate embryo sac, ×323. Fig. 21. 4-nucleate embryo sac, ×323. Fig. 22. Mature embryo sac, ×647. Fig. 23. A stage in endosperm development; note the binucleate chalazal and micropylar chambers and degenerated antipodal cells, ×323.

Megasporangium and female gametophyte.—The hypodermal archesporial cell in a young nucellar primordium (Fig. 15) directly functions as the megaspore mother cell without cutting off a parietal cell (Figs. 16, 17). It elongates and undergoes reduction division to form a tetrad of megaspores (Figs. 16–18). The tetrad is either linear (Fig. 18) or T-shaped (Fig. 19). The three micropylar megaspores degenerate and the chalazal one takes part in the development of an embryo sac of the Polygonum type (Figs. 20–22).

The mature embryo sac is fairly broad and remains within the nucellar epidermis. The egg apparatus consists of two synergids and an egg. The synergids are hooked and possess the filiform apparatus and present a degenerated appearance just before fertilization. The two polar nuclei fuse together and the secondary nucleus becomes situated near the antipodal cells (Fig. 22). The antipodal cells persist for a long time even after fertilization (Fig. 23).

Endosperm.—The primary endosperm nucleus divides in the chalazal region to form two distinct chambers, the smaller chalazal and the larger micropylar (Fig. 23). The nucleus in the chalazal chamber divides resulting in two nuclei which often become hypertrophied. The nucleus in the micropylar chamber also divides to form two daughter nuclei (Fig. 23) which by further divisions result in a large number of nuclei contributing to the general endosperm.

"*Dianella*, subtribe Dianellinæ, seems to show no close relationship with any of the subtribes mentioned so far. Although it exhibits some features like the genera of these subtribes it differs strikingly in having no cover cell over the embryo sac mother cell and epitropous ovules. The basic chromosome numbers, 8 and 9, do not coincide with those of other subtribes" (Cave, 1953). The major embryological characters and habit, undoubtedly, substantiate the affinity of *Dianella* with the tribe Asphodeleæ. However, the occurrence of trichotomosulcate pollen and the berry and the absence of cover cell over the embryo sac mother cell are in support of the relegation of the genus *Dianella* to a separate subtribe Dianellinæ which includes other genera like *Excremis* and *Styphandra*. This aberrant subtribe, Dianellinæ of the Asphodeleæ, probably, connects the next tribe, Hemarocallideæ through the genus *Phormium* which possesses simultaneous division of

pollen mother cell, trichotomosulcate pollen, Polygonum type of embryo sac development and Helobial type of endosperm.

SUMMARY

The tricarpellary superior ovary is trilocular enclosing epitropous bitegmic and crassinucellate ovules. The septal nectaries are absent.

The anthers dehisce by terminal slits and the pollen mother cells divide simultaneously. The pollen grains are two-celled at the shedding stage. They are trichotomosulcate. The tapetal cells are binucleate and enclose dense cytoplasm.

The development of the female gametophyte is of the Polygonum type, only the lowermost megaspore functioning.

The endosperm development is of the Helobial type and the chalazal chamber remains binucleate.

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STUDIES IN THE MELIACEÆ

II. Gametogenesis in *Melia azadirachta* Linn.

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INTRODUCTION

THE genus *Melia* of the family Meliaceæ comes under the order Geraniales (Engler and Prantl, 1894). The family is tropical in distribution and consists of 50 genera and 800 species (Lawrence, 1951). The form selected for the present study is commonly known as the 'Neem tree' or Margosa tree. It is well known for its bitter principle found in all parts of the plant body. Its oil is of medicinal use.

Previous work on the family appears to be very meagre. Karsten (1891) has given a short account of the late stages in embryo development and viviparity in *Carapa moluccensis* Lam. The most recent work on the family is that of Johan Wiger (1935). He has made a general survey of gametogenesis and embryogeny in some members of the family including *Melia azadirachta*. According to his work, megasporogenesis follows the Polygonum type and the fruit develops parthenogenetically. The ovules grow out unfertilized, or, if fertilized, they will be lacking in embryos. The division of secondary endosperm nucleus is independent of fertilization. The endosperm is nuclear.

MATERIAL AND METHODS

The material for the present study was collected round about Bangalore and was fixed in formalin-acetic-alcohol. The usual methods were followed for dehydration and embedding. Sections were cut at 10–16 microns and stained in Heidenhain's iron-alum-hæmatoxylin.

THE FLOWER

The floral parts arise in acropetal succession (Figs. 1–4). The flowers are bisexual, bracteate and pentamerous and are in axillary or terminal panicles. The stamens are monadelphous and are arranged in two alternating whorls (Fig. 8). The ovary is superior, syncarpous, usually with 3 locules, each locule containing 2–4 ovules on an axile placenta (Fig. 7). There are unicellular epidermal papillæ on the petals and these form an interlocking arrangement in the bud (Figs. 9–10). Only one ovule develops in each locule and the others abort. The ovary is surrounded by an annular hypogynous disc. The style is long and ends in a trilobed stigma whose epidermal cells are papillose (Fig. 5). The stylar canal is triangled (Fig. 6).
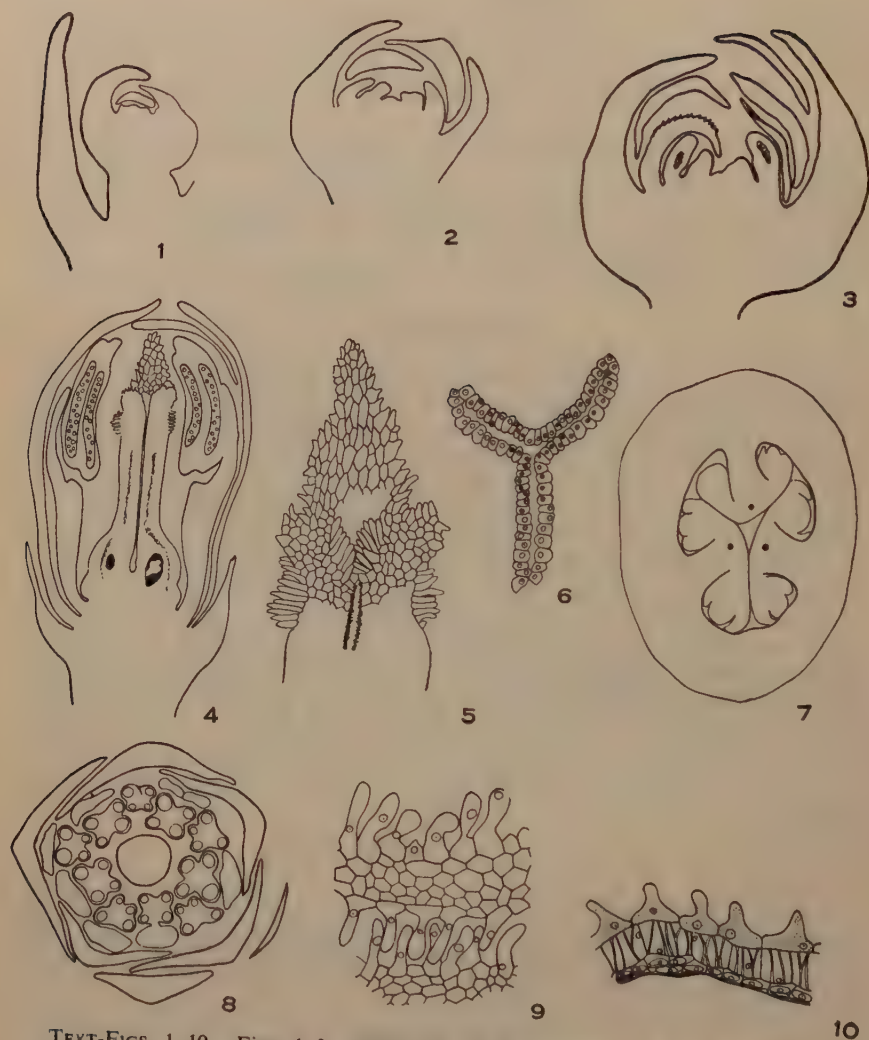
TEXT-FIGS. 1–10. Figs. 1–3. Stages in the development of the flower, ×50. Fig. 4. L.s. of a flower bud, ×50. Fig. 5. L.s. of papillate stigma, ×450. Fig. 6. The outer layer of cells of stylar canal, ×333. Fig. 7. C.s. of a young ovary, ×50. Fig. 8. C.s. flower bud at the anther level, ×50. Fig. 9. Interlocking papillæ on petals, ×333. Fig. 10. A portion of c.s. of an old anther wall, ×333.

MICROSPORANGIUM AND THE MALE GAMETOPHYTE

In cross sections a very young anther shows a rectangular group of uniform cells (Fig. 11). Gradually the four lobes become conspicuous, and at this stage the sporogenous cells can be distinguished from an outer wall consisting of a tapetal layer, three middle layers, an endothecium and an epidermis. The tapetal cells are uninucleate

at first, but later on become 2-4 nucleate by mitotic divisions, and also vacuolate (Figs. 12-13). Some of these tapetal nuclei may fuse to form polyploid nuclei later (Fig. 15). The tapetal cells remain intact till the tetrads of microspores are formed and then gradually disintegrate. The sporogenous tissue consists of a row of cells in a longitudinal section of an anther locule (Fig. 14). The middle layers become crushed in the mature anther. The endothecial cells become enlarged and develop fibrillar thickenings along their radial walls. The cells of the epidermis present a papillate appearance (Fig. 10).
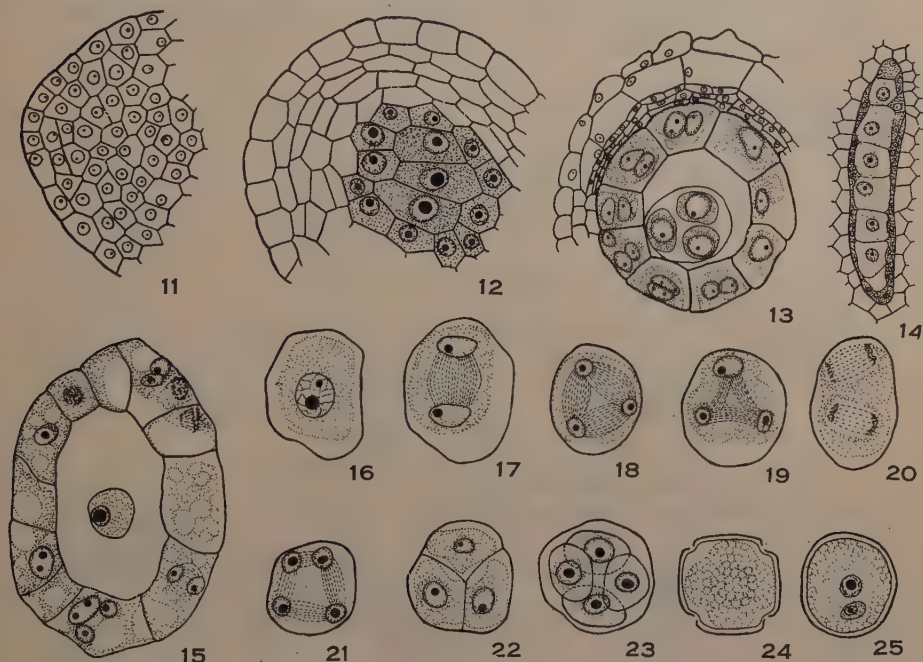
TEXT-FIGS. 11-25. Fig. 11. C.s. of young anther, ×999. Fig. 12. C.s. of the anther showing microspore mother cells, uninucleate tapetum and the wall layers, ×999. Fig. 13. Bi- and trinucleate tapetal cells, ×999. Fig. 14. L.s. of anther locule, ×999. Fig. 15. Division of tapetal nuclei, ×999. Figs. 16-25. Stages in the development of the microspores, ×500.

The microspore mother cells undergo meiotic divisions to form microspore tetrads which are usually of the tetrahedral type, but occasionally exhibit a decussate arrangement also (Figs. 16-23). The mature pollen grain has a thick exine and a thin intine. The pollen grains are tetracolporate (Fig. 24). They are shed at the bicelled stage (Fig. 25).

THE FEMALE GAMETOPHYTE

The ovule is anatropous, bitegmic and crassinucellate. The ovules arise as blunt outgrowths from the axile placenta. The inner integument appears first and it alone forms the micropyle. The hypodermal

archesporial cell becomes differentiated early and cuts off a parietal cell which divides further to produce a tissue. Consequently the megaspore mother cell becomes deep seated (Fig. 26). Both the integuments consist of 4–5 layers of cells. By the time the embryo sac is organised the cells of outer integument appear brown due to the deposits of tannin.

The megaspore mother cell undergoes reduction divisions to form a linear tetrad of megaspores. The upper three megaspores degenerate and the chalazal one develops further (Figs. 27–29). Its nucleus divides and the resulting daughter nuclei become confined to the two poles on account of a large vacuole appearing in between them (Fig. 30).
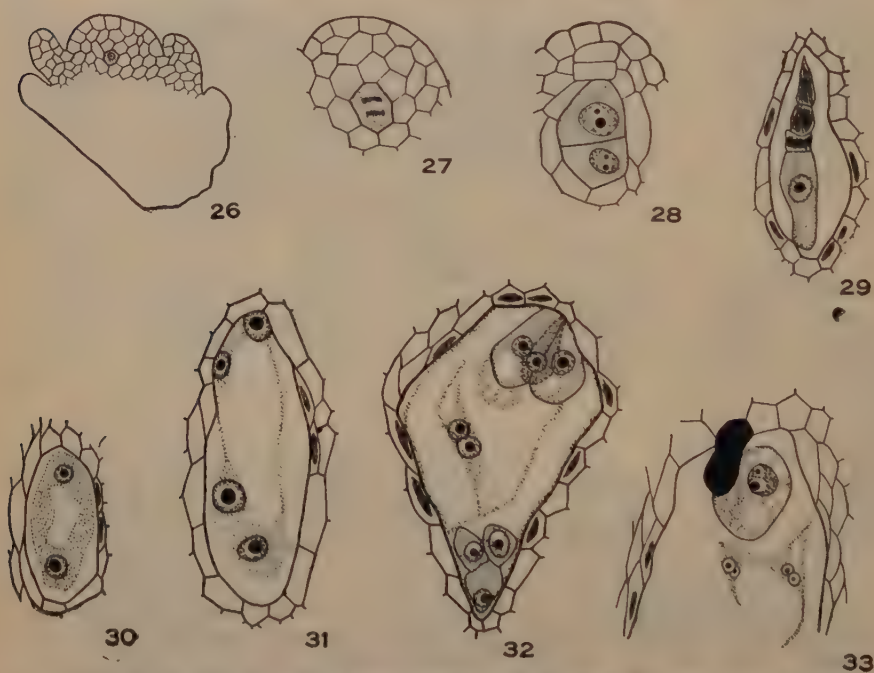
FIGS. 26–33. Fig. 26. Young ovule showing the megaspore mother cell, ×450. Fig. 27. Megaspore division, ×500. Figs. 28–30. Stages in the formation of the embryo sac, ×500. Fig. 31. 4- nucleate embryo sac, ×1,000. Fig. 32. Organied 8-nucleate embryo sac, ×1,000. Fig. 33. Fertilized egg and the nuclear endosperm, ×1,000.

The embryo sac now enlarges lengthwise and the nuclei divide again, forming a four-nucleate embryo sac (Fig. 31). By one more division of the nuclei the eight-nucleate embryo sac is formed. The egg apparatus consists of two large synergids and an egg. The antipodals are formed as comparatively small cells and are ephemeral. The polar nuclei meet in the middle of the embryo sac to form the secondary nucleus (Fig. 32). The development of the embryo sac, therefore, conforms to the Polygonum type.

Stages in double fertilization have been observed. The remnant of a pollen tube, a fertilized egg and several free endosperm nuclei are shown in Fig. 35. The endosperm is of the free nuclear type. It forms a tissue at a very late stage in the development of the seed.

SUMMARY

The floral parts arise in acropetal succession. The epidermal cells of the petals and anthers are papillate and interlocking. The parts abound in tannin cells.

The anthers are monadelphous. The microspores are usually arranged tetrahedrally. The pollen grains are tetracolporate and are shed at the bicelled stage. The ovary is superior and is surrounded by a hypogynal annular disc. There are two ovules in each of the three locules.

The ovules are anatropous, bitegmic and crassinucellate.

The development of the embryo sac conforms to the Polygonum type.

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SPONTANEOUS CHROMOSOME INVERSIONS IN *CHLOROPHYTUM ELATUM* R. Br.

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INTRODUCTION

INVERSION hybrids are of great importance in the analysis and significance of structural hybridity in plants and animals. The occurrence of spontaneous chromosome inversions is usually so rare that no adequate analysis can be made of the types and frequency of their appearance. Further, it is seldom possible to determine the stage at which the aberrations occurred. However, aberrations which are heterozygous result in characteristic chromosome configurations visible at meiosis. Darlington (1937) has reviewed work on these aspects and has referred to investigations of McClintock, Mather, Lamm and others in plants, and of Sturtevant, Beadle, Dobzhansky and others in animals. He has also made references in this regard to unpublished works of Upcott in the genera *Tulipa* and *Tradescantia*, Frankel in *Fritillaria*, Daughty in *Agave* and Sutton in *Pisum*. More recently, Dobzhansky (1955) has made frequent references to inversion heterozygosis in organisms with particular reference to certain *Drosophila* populations and has pointed out the genetic role of inversions in evolution.

Meiotic studies on the material under the present investigation were started some years ago and a paper embodying certain preliminary cytological observations was read before the Botany Section of the Indian Science Congress at Hyderabad (Sheriff, 1952), under the name *Anthericum elatum* for the species. The author had the opportunity to visit Kew Botanical Gardens, England, and get at the current name of the species as *Chlorophytum elatum* R. Br. Subsequent investigations on a population of the species have revealed a rather high incidence of inversion heterozygosis with a remarkable variety of meiotic and allied irregularities. In the present contribution, a detailed analysis of the abnormal meiotic configurations is presented. An attempt is made to interpret them, and their significance is discussed in the light of modern concepts.

MATERIAL AND METHODS

Chlorophytum elatum R. Br. (2 *n* = 28), is a member of the tribe *Asphodeleæ* of *Liliaceæ* (Hutchinson, 1934). Chittenden (1951) refers to the green house variety as *Chlorophytum elatum variegatum* (= *Anthericum elatum*). Bailey (1919) refers to it merely as *Chlorophytum elatum* (= *Anthericum vittatum*, = *A. picturatum*, = *A. williamsonii*, Hort.). The plant is grown in gardens and greenhouses for its striped foliage and is principally propagated by offsets. It has fleshy white roots and

the leaves are green with yellowish white bands along the margin. The paniculate scape is green. The plant frequently produces clusters of bulbils on the inflorescence. The material for study was obtained from gardens of Bangalore (Mysore State, South India) and Ootacamund Hill Station (Nilgiri). Permanent aceto-carmin squash preparations were made both with fresh as well as stored material previously fixed in acetic alcohol. Feulgen preparations were also made. All drawings were made at the table level with a camera lucida. Photographs were made from permanent preparations.

<div align="center">OBSERVATIONS</div>

Both pericentric and paracentric inversions result in the reverse pairing of the loop at pachytene and it is difficult to observe the pachytene inversion loops. Text-Fig. 1 shows a pollen mother cell at pachytene stage illustrating the pairing and relational coiling of the chromosomes. Text-Fig. 2 represents a late diplotene stage. The characteristic pattern of the fourteen bivalents and the chiasmata may be noted. The later behaviour which characterizes an inversion heterozygote, manifests only when crossing-over has taken place between the two relatively inverted segments. The behaviour also depends upon the number of crossings-over and their mutual relationship, *viz.*, reciprocal, complementary or diagonal. The several kinds of configurations met with in the present material can be considered under the following heads:

1. *Configurations at meiotic anaphase I and II*

(*a*) Text-Figs. 3, 4, 5 and Plate VIII, Fig. 1 represent pollen mother cells at anaphase I, each showing the formation of a single-chromatid bridge and an a-centric fragment. Each of these cells is at a different stage of development. The snapping of the bridge and the inclusion of the fragment in one of the daughter cells is clearly visible. This kind of configuration can be explained by assuming the formation of a single chiasma or two diagonal chiasmata in the inversion; or a single chiasma proximal to the inversion which is reciprocal or complementary to the chiasma in the inversion.

(*b*) Text-Fig 6 and Plate VIII, Fig. 2 illustrate a pollen mother cell at anaphase I and the formation of a two-chromatid bridge with the elimination of two a-centric fragments. Such a configuration can be interpreted by assuming the occurrence of two complementary chiasmata in the inversion. Text-Fig. 7 shows the snapping of the double chromatid bridge.

(*c*) A chiasma proximal to the inversion which is diagonal to the chiasma in the inversion results in a loop chromatid, two normal chromatids and an a-centric fragment. While a chiasma proximal to the inversion which is diagonal with respect to complementary chiasmata in the inversion, results in two loop chromatids and two a-centric fragments. In both cases the first anaphasic separation would be apparently normal with elimination of the fragment or fragments, but the loop chromatid in either case will form a bridge at anaphase II. Text-Figs. 9–11 are

TEXT-FIGS. 1–9. Fig. 1. Pollen mother cell at pachytene stage. Fig. 2. PMC at late diplotene. Fig. 3. PMC at meiotic anaphase I showing the single-chromatid bridge and a fragment. (The other bridge-like configuration is probably due to late anaphasic separation of a bivalent.) Figs. 4 and 5. PMCs at anaphase I showing the snapping of the single-chromatid bridges and the inclusion of the fragment in one of the daughter cells. Figs. 6 and 7. PMCs at anaphase I illustrating the formation of double-chromatid bridge and two fragments. The bridge has snapped in the latter. Fig. 8. PMC at anaphase I showing the apparently normal separation and the elimination of two fragments. Fig. 9. PMC at anaphase II with a second division bridge and a fragment. (All figures, ×1,350 except Figs. 4 and 5, ×900.)
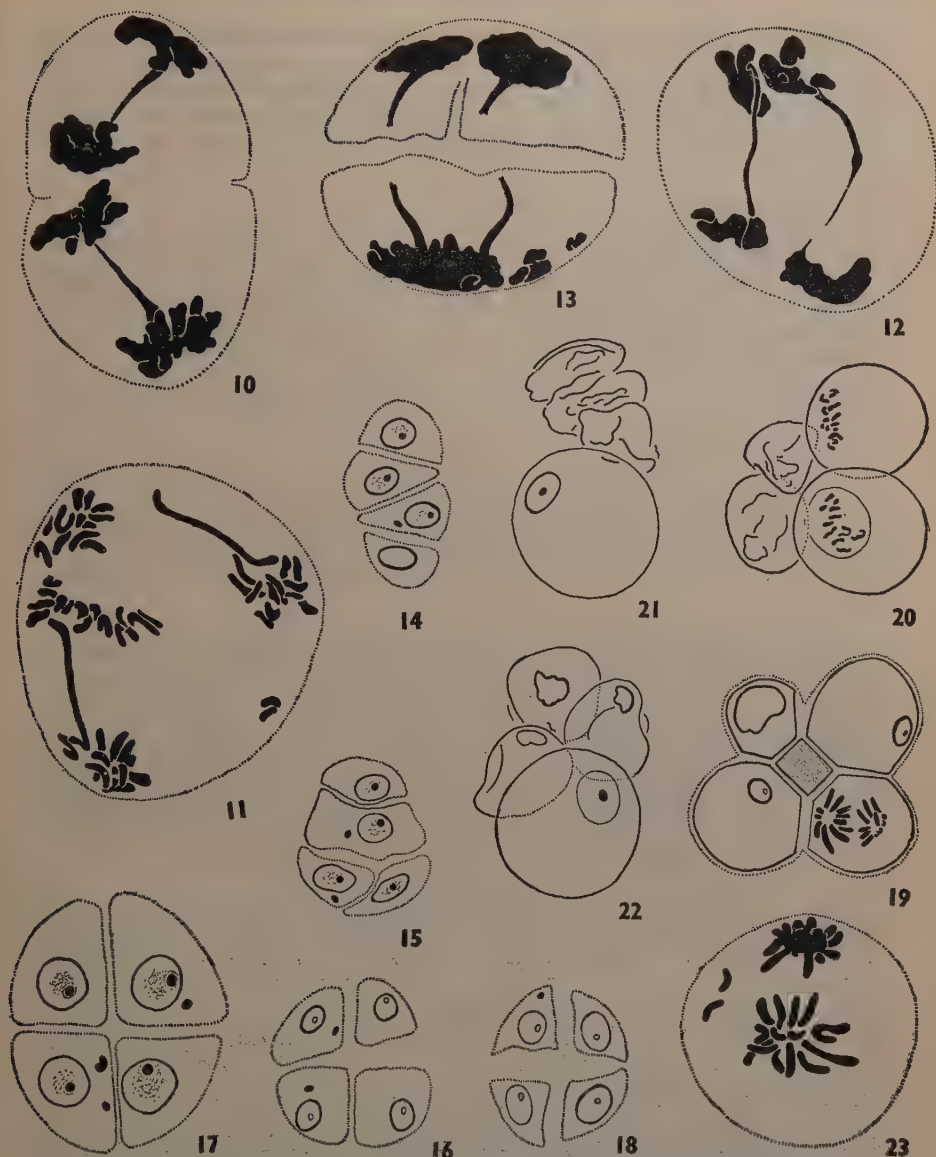
Text-Figs. 10–23. Figs. 10–13. PMCs at meiotic anaphase II showing the formation of second division bridges. The snapping of bridges in Fig. 13 may be noted, ×1,350. Figs. 14–18. Tetrads of pollen grains in which a few grains show the persisting fragments. The variety of pollen tetrad formation may be noted, ×600 (except Fig. 17, ×800). Figs. 19–22. Stages in the development of pollen grains showing different degrees of degeneration ranging from one to three, ×600. Fig. 23. Pollen grain in the first mitotic division showing the two bodies towards the left inside the cell which apparently represent a divided fragment, ×1,350.

apparently illustrations of such cases. The second division bridge and the fragment in Text-Fig. 9 and Plate VIII, Figs. 3 and 4, may be noted. The elimination of the two fragments in Text-Fig. 9 and Plate VIII, Fig. 5 and the formation of two second anaphase bridges are clearly visible in Text-Figs. 10 and 11 (and Plate VIII, Fig. 6). Text-Figs. 12 and 13 show snapping of the bridges.

2.   *Abnormalities in pollen grains*

The formation and structure of pollen grains reveal further interesting evidences of inversion hybridity in the population. Text-Figs. 14–18 represent groups of pollen grains at the tetrad stage showing the persisting fragments in the cytoplasm of some of them. Text-Figs. 19–22 are apparently illustrations of lethal effects due to losses suffered by chromosomes as a result of crossing-over in inversions. Different degrees of degeneration of pollen grains during their development may be noted.

3.   *Pollen grain mitosis*

Text-Fig. 23 shows a pollen grain in the first mitotic division.   The two bodies lagging towards the left presumably constitute a divided fragment which has persisted even upto this late stage. Darlington (1937) has mentioned only one such case (in *Podophyllum*).

DISCUSSION

The nature and role of inversions, both spontaneous and induced, in populations of organisms, have been topics of much discussion. Originally chromosomal rearrangements including inversions were supposed to be neutral biologically and such features were grouped under " Natural Polymorphism ".   Recent researches, however, particularly those on different species and races of *Drosophila* have shown that chromosomal rearrangements are active evolutionary agents and there are evidences to state that certain populations heterozygous for inversions possess heterotic superiority over normal ones.

It is well known that inversion heterozygosis often results in meiotic irregularities which may produce changes in the number and morphology of chromosomes.   These changes are associated with the mode of pairing and crossing-over in hybrids.   The present studies amply demonstrate several kinds of such irregularities.   The frequency of the irregularities of the types investigated, varied with the individual plants (ranging from 0·04–0·18%), which is quite significant. Observations on seed setting indicate that in certain fruits the production of seeds is relatively less which may be probably connected with the formation of some number of inviable gametes.   Otherwise the fertility is not much affected, which is perhaps due to effective suppression of crossing-over. Darlington (1937) has pointed out that " the importance of inversion hybrids in a natural population depends to some extent on the normal results of crossing-over in giving new types of chromosomes but to a much greater extent, at least in diploids, on their effect in suppressing effective crossing-over and, therefore, holding groups of genes together".

The occurrence of a population heterozygous for a number of inversions, in a horticultural group of plants under the name *Chlorophytum*

elatum with certain amount of systematic confusion involved in the green-house varieties, appears to be significant and raises interesting genetical and evolutionary problems. Since inversions involve changes only in the arrangement of genes on the chromosome, organisms both hetero-as well as homozygous for inversions, should have the same genes. From this it would appear that the phenotypic appearance and the physiology of the individual should not cnange by the occurrence of such aberrations. This is said to be often true but there are exceptions. Dobzhansky (1955) has referred to the existence of populations of many species consisting of two or more " phases " differing in colour or some other traits. He has also cited instances of certain *Drosophila* popula-tions in which flies homo- and heterozygous for certain inversions look alike but, nevertheless, individuals heterozygous for inversions clearly exhibit greater vigour and a nigh ecological adaptive value. He has stated that " the phenotypic manifestations of genetic polymorpnism in Mendelian populations may or may not be very conspicuous. There are instances in which the rearrangements of genes result in some of these genes behaving as though they had suddenly become unstable and had undergone frequent changes or mutations. The latter behaviour gives rise to *spotted* or *mosaic* distribution of colours or other traits not un-common among garden varieties and some ornamental plants".

Viewed in the light of the foregoing considerations, the existence of a population heterozygous for inversions within the species under the name *Chlorophytum elatum* becomes understandable. The presence of such a population possessing efficient methods of vegetative reproduc-tion as a safeguard against the risk of any reproductive inferiority (game-tic sterility) strongly indicates that we are dealing with a ploymorphic species in *Chlorophytum elatum* and the population under study may be a definite genetic line. Further work on other garden varieties may throw more light on these interesting problems.

SUMMARY

1. Cytological investigations have revealed that a population of *Chlorophytum elatum* is heterozygous for a remarkable variety of spon-taneous chromosome inversions.

2. An analysis of several meiotic and allied configurations bearing on inversion heterozygosis is presented.

3. An attempt is made to interpret the meiotic irregularities.

4. The persistence of fragments in pollen grains and the lethal effects of crossing-over in inversion heterozygotes resulting in early degeneration of pollen, have been demonstrated. The persistence of a divided fragment even upto the first mitotic division of the pollen grain is illustrated.

5. The significance of inversion heterozygosis in organisms is dis-cussed and the probability of *Chlorophytum elatum* representing a poly-morphic species and the population under the present study representing a definite genetic line characterized by inversion hybridity, is suggested.

ACKNOWLEDGEMENTS

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EXPLANATION OF PLATE VIII

Fig. 1. PMC at anaphase I showing the first division single-chromatid bridge and the a-centric fragment. Fig. 2. Photograph of cell shown in Text-Fig. 6. Figs. 3 & 4. PMCs at anaphase II, the former showing the single bridge only and the latter showing the bridge and fragment. Fig. 5. Photograph of cell shown in Text-Fig. 8. Fig. 6. Photograph of cell shown in Text-Fig. 11. (All photographs, ×700.)
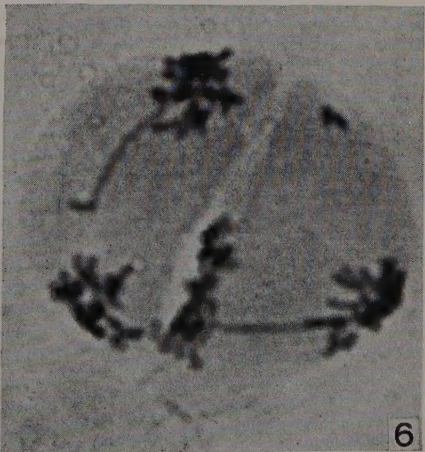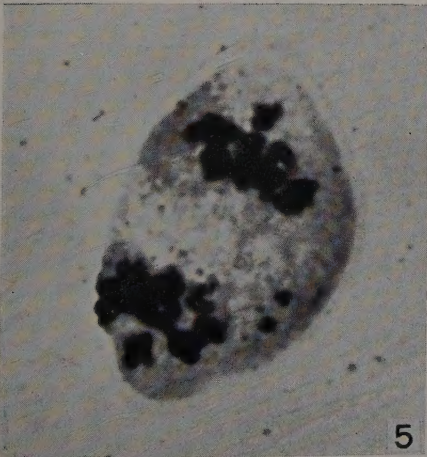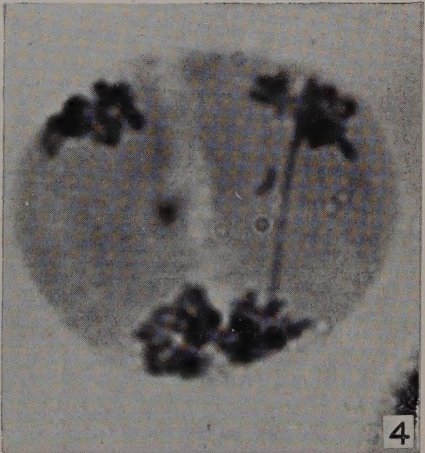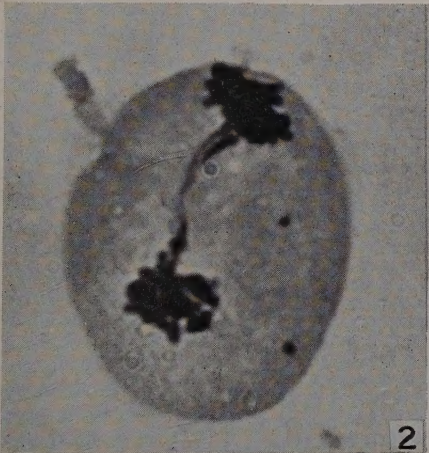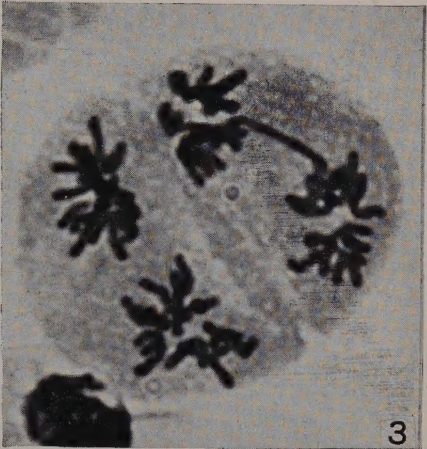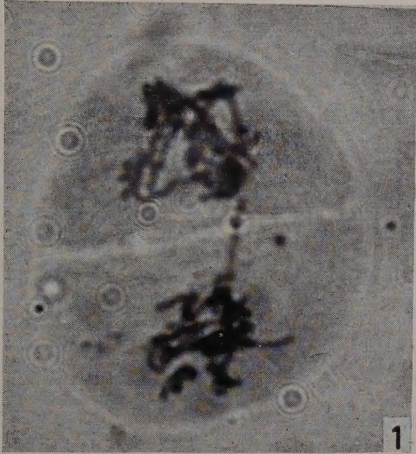
REVIEW

Rice in Orissa. Published by the Home (Public Relations) Department, Government of Orissa, Bhuvaneshwar, 1956. Price Rs. 7·00.

This publication of the Orissa Agricultural Department has been released to synchronise with the visit of the members of the International Rice Commission to that State. Dr. Chalam, Paddy Specialist, and six of his colleagues have presented in a concise manner the work done to date on rice in Orissa.

The general features of rice cultivation are described in detail. Only a fifth of the area sown to rice in the State has assured irrigation facility and possibly this is the main reason for the low average acre yield of 500 lb. It is but half of the all-India average and since rice is the only food crop of the State, the need for stepping up yields is urgent.

Systematic rice improvement work in Orissa was started only in 1932 and it was intensified with the separation of the State from Bihar in 1936. The Orissa Rice Research Scheme initiated in 1938 with the financial assistance of the Indian Council of Agricultural Research provided additional staff and facilities. Besides work on varietal improvement, physiological studies carried out under this scheme have given valuable results. A key for classification in rice has been drawn up based principally on 13 spikelet colours, each of which was further subdivided based on the colour of the kernel, sheath, stigma, apiculus, awn character and size of the spikelet. Dr. K. Ramaiah of the Food and Agricultural Organisation, however, feels that such a key of classification will be of limited use as the number of varieties is large and advocates tabulation of over 30 morphological characters as a better guide for the identification of the varieties. The early work was restricted to the evolution of high yielding strains in local varieties. Outstanding among these are, BAM 3 and saline-resistant strain S.R. 26 B, which are very popular in Andhra and Madras State as well. The system of nomenclature for the strains released from Orissa (*vide* pp. 88/95) requires standardization. The spread of improved strains in the State is reported to be only 10% and plans are on hand to accelerate it.

Hybridization work has not made much progress in Orissa. This has been found to be a very useful technique to reduce the large number of varieties under cultivation and also combine useful characters now found widely distributed. Intensive studies have been taken up recently in the *japonica* × *indica* crosses and some very interesting results achieved, besides spotting two good cultures for release as strains. Agronomic experiments have revealed the optimum spacing, seed rate, age of transplanting, etc., for the different seasons and tracts in the State. Similarly, efficient manurial schedules have been drawn up based on the results of numerous experiments. The effect of trace elements on yield has been studied and some interesting indications obtained.

The Japanese method of paddy cultivation is being popularized. Manuring of seed beds advocated as per this system is of doubtful value as the experiments conducted in the State have shown that this is an ineffective practice (*vide* p. 68). In respect of spacing and manuring of the transplanted field the method has been modified to suit local conditions.

The book is a welcome addition to the scanty literature on rice in India. The printing and get-up are excellent. But one feels that the cost of Rs. 7·00 for a book of 124 pages is rather high and this is due to the inclusion of 34 plates and 11 graphs, some of which could be omitted without decreasing the utility of the publication. An index and a plan of the State are wanting and it is hoped this defect will be made good in future editions.

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